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Sacramento
and
San Joaquin
River Basins

Comprehensive Study

TECHNICAL STUDIES DOCUMENTATION

APPENDIX G

ECOSYSTEM FUNCTIONS MODEL

THE RECLAMATION BOARD
PUBLIC SAFETY
WITH FLOOD PROTECTION
STATE OF CALIFORNIA

US Army Corps
of Engineers
Sacramento District

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ECOSYSTEM FUNCTIONS MODEL

The Sacramento and San Joaquin Rivers Comprehensive Study was authorized by the U.S. Congress and the California State Legislature in response to the floods of January 1997. The purpose of the study is to (1) reduce flood damage and (2) integrate ecosystem restoration. In order to understand how actions to reduce flood damage can affect the ecosystem and identify the opportunities for ecosystem restoration along lower Sacramento and San Joaquin Rivers, an Ecosystem Functions Model (EFM) has been developed.

The Ecosystem Functions Model is intended to predict how aquatic and terrestrial ecosystems along a river reach may be impacted by the implementation of floodway management measures or changes to flow regime. The EFM can evaluate and compare existing conditions, with-project, and without-project conditions. Using input variables such as flow, existing vegetation, and topography, the model evaluates how changes in flow regime and riverine morphology would impact key attributes of the river-floodplain ecosystem.

TECHNICAL APPROACH AND MODEL DEVELOPMENT

The EFM uses a set of identified functional relationships between river flow, floodway morphology, and the biological communities that inhabit the channels and floodplain lowlands of the Sacramento and San Joaquin River basins. The EFM is a valuable planning tool in that it can anticipate biological consequences that may not be fully realized for many decades. Flow data and floodway characteristics for existing and with-project conditions are processed through the functional relationships of the EFM to produce basic indicators of biological change.

The model is capable of simulating flood damage reduction and environmental restoration measures that change the flow regime or physical characteristics of the floodway. Changes to the flow regime could result from reservoir reoperation, new flood storage, changes to weirs, or other measures that affect the timing or magnitude of flood peaks. Changes to the characteristics of the floodway could include the construction or modification of levees, new bypass channels, reconnection of oxbows or other hydrographic features, or channel modifications. The EFM predicts how these changes to the flood management system could maintain, degrade, or enhance terrestrial and aquatic biological activities. For example, the outputs of the EFM could indicate changes in the extent of suitable riparian seedling establishment areas, the extent of seasonally inundated aquatic habitats, or key environmental flow conditions that would result from a proposed measure.

The EFM is not a single computer model or program; rather, it is a process for evaluating biologic, hydrologic, and hydraulic variables that can be applied to multiple study areas and alternative conditions. As shown in **Figure 1** and described below, there are five major steps involved in the EFM:

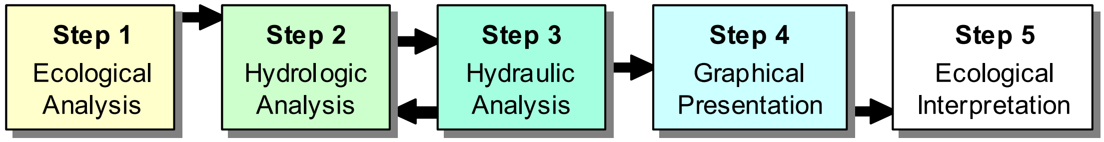

FIGURE 1 – EFM PROCESS

Step 1. Ecological Analysis - The ecological analysis identifies functional relationships between river hydrologic and hydraulic conditions and the riverine ecosystem/geomorphic system. These relationships reflect requirements of different habitat types in terms of streamflow durations, return periods, and stage recession rates. The biological effects of overbank flow are a major focus of the ecological relationships. The ecological analysis consists of two major elements: the terrestrial ecosystem and the aquatic ecosystem:

- **Terrestrial ecosystem** - The terrestrial element focuses on the establishment and initial survival of riparian and wetland vegetation. It evaluates criteria for suitable flows and topography to promote seedling establishment and avoid post-establishment losses due to insufficient soil moisture and/or flood scouring.
- **Aquatic ecosystem** - The aquatic element focuses its analysis on the seasonal inundation of floodplains and flood bypasses to evaluate potential impacts and benefits to two representative native fishes, Sacramento splittail, and Chinook salmon smolts. This element incorporates criteria for suitable overbank flows to benefit floodplain spawning, rearing, foraging/migration, and avoidance of stranding, and predicts spatial changes in the extent of suitable floodplain habitat.

The terrestrial and aquatic functional relationships are described in greater detail later in this document.

Step 2 - Statistical Hydrology Analysis – This analysis translates the ecosystem relationships developed in Step 1 into discharges with specified durations, return periods, seasonal periods, and stage recession rates. The statistical analysis uses historical, existing, and/or post-project conditions from modification of reservoir operations, river levee setback, and additional transitory storages, etc. The analysis is conducted in MS Excel. The ecosystem requirements and statistical analysis developed in MS Excel are coded into a generalized FORTRAN computer software package. This step is described in greater detail later in this document.

Step 3 - Hydraulic Analysis – This analysis determines the hydraulic responses of discharges estimated in step 2. The statistically determined discharges form the input to a hydraulic model for the calculation of corresponding stages and flood inundation areas. HEC-RAS, a hydraulic model developed by the Corps of Engineers is used in conjunction with ArcView and the HEC-GeoRAS and 3D Analyst extensions. These programs were used because geometric data and hydraulic results can be iteratively exported from Arc View into HEC-RAS and back into Arc View for processing and spatial analysis.

Step 4 - Graphical Presentation – The geographic analysis step involves the use of a geographic information system (GIS), such as ArcView, to geographically overlay hydraulic results with other ecological and environmental information. Data used in the geographic analysis includes vegetative cover, soil types, land use, historic topography, ground water elevations, and the digital terrain maps. GIS provides a platform to display and compare results, allowing ecologists to evaluate how proposed flood management measures and ecosystem restoration measures will affect existing terrestrial and aquatic habitat.

Step 5 - Ecological Interpretation – The final step in the EFM is the interpretation of results presented in the graphic analysis step. Because ecological systems can be incredibly complex, it is important that EFM results are reviewed and interpreted by experts who are familiar with the ecology of the study area. Ecologists review the spatial and tabular output, along with other relevant data, and make comments and/or recommendations on the proposed flood management and ecosystem restoration measures.

While the basic construct or process of the EFM is expected to remain the same, there is flexibility in the analysis tools and methods that can be used to perform the five analysis steps. Thus, the EFM can adapt to the needs and characteristics of future projects or study areas. For example, the Comprehensive Study has developed many biological relationships for use in the ecological analysis component, but future studies may develop additional relationships for specific regions or study areas. Similarly, a DOS-based computer program was developed to automate the statistical hydrology and ecological analysis components; this program can be used and modified, as necessary, in future applications of the EFM. The hydraulic analysis component can also be performed using other hydraulic tools or models.

TERRESTRIAL AND AQUATIC RELATIONSHIPS

The functional relationships in Step 1, the ecological analysis component, form the foundation of the EFM. The relationships currently used by the EFM were developed by a team of biologists, ecologists, and hydrologists from the comprehensive study, Jones & Stokes Associates, Northwest Hydraulics Consultants, and the Hydrologic Engineering Center (HEC) of the US Army Corps of Engineers. The relationships are specific to the Sacramento and San Joaquin rivers. The development of some of the elements was deferred to future studies due to time constraints, as noted below. A detailed discussion of the development of the relationships is presented in F*inal Functional Relationships for the Ecosystem Functions Model*, December 2000, and summarized below.

Terrestrial Ecosystem Element

The terrestrial ecosystem element consists of five components, A through E, and various sub-elements, as shown in **Table 1** and discussed in the following sections.

TABLE 1
COMPONENTS OF THE TERRESTRIAL ECOSYSTEM ELEMENT

Sub-Element	**Description**	
I A - Potential Riparian and Wetland Zones		
	A-1	Substrate characteristics
	A-2	Depth of water table
	A-3	Flood events suitable for plant germination and establishment
	A-4	Scour regime of riparian zones
	A-5	Scour and inundation of active channel habitats
I B - Rates of Ecosystem Change		
	B-1	Rates of channel migration
	B-2	Frequency and intensity of flood scour
	B-3	Tendency for degradation or aggradation
	B-4	Rates of overbank germination flows
	B-5	Rates of vegetation succession
I C - Connectivity to Aquatic Habitats		
I D - Land Use Constraints		
I E - Wildlife Habitat Suitability		

IA - Potential Riparian and Wetland Zones

Several criteria are used to define areas that have, or would have in response to a proposed measure, physical characteristics suitable for the development of riparian or wetland habitat. These areas can be divided into five zones, described below:

Zone 1 - Active Channel Habitats: riverwash and herbaceous riparian habitats characterized by active sand/gravel bars and/or areas frequently inundated and exposed to scour (within zone of bankfull discharge).

Zone 2 - Riparian Willow Scrub: higher elevations bordering the river channel that experience less frequent inundation than Zone 1, but frequent flood disturbance and scour.

Zone 3 - Cottonwood Riparian Forest**:** areas with less frequent flood disturbance than Zone 2.

Zone 4 - Mixed Riparian Forest: higher shelves at a greater distance from the river than Zone 3, characterized by floodplain terraces with less physical disturbances.

Zone 5 - Freshwater Marsh and Associated Wetlands: clayey soils inundated for long periods of time and subject to significant flow/velocity only during large flood events, including large overflow basins and smaller wetland features, such as oxbows.

Category 1A was divided into five sub-criteria to characterize the potential extent of each habitat zone within a given study reach:

IA-1 Substrate characteristics, including sediment and soil characteristics

IA-2 depth to water table

IA-3 frequency and seasonality of flood events suitable for plant germination and establishment (resulting in inundation)

IA-4 scour regime of potential riparian zones (Zones 2, 3, and 4), characterized by the frequency of scouring flows

IA-5 scour and inundation of active channel habitats, used to define boundary of the active channel (Zone 1) and riparian willow scrub (Zone 2)

IB - Rates of Ecosystem Change

Relationships were developed to characterize the rates of habitat renewal and other ecosystem changes, which are indicators of ecosystem health. Habitat renewal and other changes are influence by the rate of channel migration; other vegetation disturbances (i.e. floodplain scour and deposition, disease, windthrow, fire, etc.); rate of events suitable for germination and plant establishment; and vegetation succession rates. The five sub-elements developed to characterize the rates of ecosystem change are described below.

IB-1 Rates of Channel Migration **-** To estimate potential change in rates of channel migration due to an alternative action, the degree of natural/existing channel migration in the subject reach must first be estimated. The direction of change resulting from a proposed action is then estimated by relating changes in a specific flow parameter to the existing rate of channel migration.

IB-2 Frequency and Intensity of Flood Scour **-** Frequency of flood scour is also incorporated into two of the sub-elements that define potential riparian zones (see sub-elements IA-4 and IA-5, above).

IB-3 Tendency for Degradation or Aggradation – This sub-element was deferred to future studies.

IB-4 Rates of Overbank Germination Flows **-** Frequency of germination flows has been incorporated into an element that defines the potential riparian willow scrub zone (Zone 2) and the cottonwood riparian forest zone (Zones 3) (see also sub-element IA-3, above).

IB-5 Rates of Vegetation Succession – This sub-element was deferred to future studies.

IC - Connectivity to Aquatic Habitats

The degree of connection of riparian habitats to aquatic habitats, providing seasonal rearing habitats, depends upon the extent, timing, depth, duration, rate of recession, and frequency of overbank flows. Development of this element was deferred to later studies.

ID - Land-Use Constraints

This element was deferred to future studies.

IE - Wildlife Habitat Suitability

Wildlife habitat suitability depends primarily upon the type and acreage of potential and actual habitats; structural characteristics of those habitats; rate of channel migration (e.g., for bank swallow); and the floodplain inundation regime (frequency of flooding). Development of this element was deferred to future studies.

Aquatic Ecosystem Element

The aquatic ecosystem element consists of two parts: in-channel habitats, and seasonally inundated floodplains and flood bypass habitats. The in-channel component includes relationships that reflect the dependence of suitable substrate, instream cover, and bank vegetation on changes in flow regime and channel morphology. The floodplain component incorporates conditions for suitable overbank flows that benefit floodplain spawning, rearing, and avoidance of stranding, used to predict spatial changes in the extent of suitable floodplain habitat. In the Sacramento and San Joaquin River basins, the stream channel component supports aquatic species throughout the year while floodplains and flood bypasses provide essential seasonal habitats that are different from those that occur in the stream channel alone. This variety contributes to increased species population productivity, and potentially increases the resilience of the population to annual fluctuations in environmental conditions. The aquatic ecosystem sub-elements are listed in **Table 2**.

TABLE 2
COMPONENTS OF THE AQUATIC ECOSYSTEM ELEMENT

Sub-Element		**Description**
Stream Channel		
II E - Juvenile Rearing and Movement		
	E-1	Rearing Habitat Abundance
Floodplain and Bypass		
II B - Adult Spawning and Egg Incubation		
	B-1	Spawning Habitat Abundance
II C - Juvenile Rearing and Movement		
	C-1	Rearing Habitat Abundance
	C-3	Habitat Connectivity

The aquatic relationships were selected based on two broad premises. First, habitat abundance and quality affect fish population abundance, distribution, food resources, predation, and competition. Second, ecosystem processes and physical structure, primarily geomorphic and hydrologic, drive the structure and dynamics of the river and floodplain, and the subsequent creation/maintenance of fish habitat.

Relationships included in the aquatic element of the EFM provide a measurement of ecosystem attributes that affect the abundance and distribution of socially/politically important fish species, including those that are important to sport fishing and listed under the Endangered Species Act. The functional relationships focus on factors that affect the life stages of salmonids and Sacramento splittail, which act as representatives of the entire aquatic community.

Stream Channel

The stream channel element represents life history events in the life cycle of Chinook salmon: adult migration, adult holding and spawning, egg incubation, and juvenile rearing and movement. Restoration and maintenance of Chinook salmon populations requires successful completion of all four life history events. Chinook salmon were selected as the representative species for the stream channel because they are sensitive to an important cross section of ecosystem attributes; are native to the system; use a range of habitats important to other native species in the aquatic community; and are targeted for restoration under federal and state programs.

Development of relationships for adult migration, adult holding and spawning, and egg incubation has been deferred to future studies.

IIE - Juvenile Rearing and Movement - Key factors for successful rearing and movement of juvenile fish include rearing habitat abundance, suitable water temperature, minimization of diversion losses, and absence of passage barriers. The rearing habitat abundance sub-element is described below. The water temperature element was not developed at this time because water temperature modeling, particularly resulting from proposed actions, was beyond the scope and schedule of the Comprehensive Study. Diversion losses are reflected in seasonal hydrology, and fish passage barriers can be identified on a project-by-project basis.

IIE-1 Rearing Habitat Abundance - Key relationships at the ecosystem level that define suitable rearing habitat include 1) flows needed to maintain suitability of spawning gravel substrates for early rearing, 2) flows sustaining sufficient channel migration to assure maintenance of channel complexity, and 3) presence of woody bank vegetation to provide overhead cover and instream cover recruitment during channel migration.

Floodplains And Flood Bypasses

The floodplain and flood bypass model element has three sub-elements representing life history events in the life cycle of Chinook salmon and splittail. Splittail are included in the relationships because their habitat needs encompass additional attributes relative to timing, magnitude, and duration of flood events.

The major life history events include adult migration for Chinook salmon, adult spawning and egg incubation for splittail, and juvenile rearing and movement for Chinook salmon and splittail. Key habitat relationships presented below are focused on floodplain inundation potentially important to both Chinook salmon and splittail.

IIB - Adult Spawning and Egg Incubation - Seasonally inundated floodplain and flood bypasses provide important spawning habitat for splittail. Sub-element IIB-1 characterizes spawning habitat abundance. The availability of spawning habitat for splittail is related to flood timing, magnitude, duration, and frequency relative to floodplain and flood bypass morphology.

IIC - Juvenile Rearing and Movement - Rearing of juvenile splittail and Chinook salmon coincides with winter flood events that inundate floodplains and flood bypasses. High flows also appear to increase the density of juvenile Chinook salmon in downstream habitats, including the large expanses of floodplain and flood bypasses in the lower segments of large rivers. Key factors affecting rearing success include habitat abundance, predation, and connectivity with the river channel. The predation sub-element was deferred to future studies, and the habitat abundance and connectivity sub-elements are described below.

IIC-1 Rearing Habitat Abundance. The area of habitat for rearing by juvenile Chinook salmon and splittail is related to flood timing, magnitude, frequency, and duration relative to floodplain and flood bypass morphology.

IIC-3 Habitat Connectivity. Connectivity is the opportunity for fish to return to the main river channel during the period of falling stage after a flood event. Suitable floodplain rearing habitat is dependent on topography, which should slope to a main channel or slough to facilitate complete drainage and avoid stranding of adults, larvae, and juveniles in depressions or other low-lying floodplain features.

STATISTICAL HYDROLOGIC ANALYSIS

Step 2 of the EFM requires a statistical hydrologic analysis. The hydrologic analysis develops the information needed to evaluate the functional aquatic and terrestrial relationships, such as the timing, magnitude, duration, or frequency of certain flood events. Historic gage data at nearby gaging stations is the primary source of input for the hydrologic analysis. As summarized in **Table 3**, eleven of the functional relationships require hydrologic information. The eleven ecosystem requirements were grouped into five different categories to facilitate the statistical analysis:

Category 1 Estimating flows (stages) with different return periods on an annual basis (elements 1A-4, 1B-1, 1B-2, 2C-3, and 2E-1(b))

Category 2 Estimating monthly average flows (stages) for the specified months (elements 1A-2, 2C-3, and 2E-1(c))

Category 3 Deriving stage (flow)-duration-frequency relationships for different seasons (elements 2B-1 and 2C-1)

Category 4 Deriving stage decline rate-duration-frequency relationships for different seasons (elements 1A-3 and 1B-4)

Category 5 Deriving highest stage sustained for 21 days for events that meet Criteria 1A-3 (elements 1A-5, 1B-2, and 2E-1(C))

Category 1 – Flow Frequency

Flow (stage) in Category 1 can be estimated from an empirical flood-frequency curve developed from historic data. A sample peak flood frequency curve is shown in **Figure 2** for the San Joaquin River at Vernalis, based on USGS recorded daily flows.

TABLE 3
INPUT REQUIREMENTS FOR TERRESTRIAL AND AQUATIC RELATIONSHIPS

Sub-Element Name		Statistical Requirement	Ecological Response
Element I – Terrestrial Ecosystem			
IA-1	Substrate Characteristics	1. None	Optimal soil suitability for various plant communities. Use soils maps to identify soils
IA-2	Depth of Water Table	1. Average August Flow (Stage)	Average water table depth in later growing season.
IA-3	Flood Events Suitable for Plant Establishment	1. Time period=April 1-July 15 2. Stage decline rate<=0.88 feet/week 3. Return period<=10 years	Overbank flows in seed release periods that recede slowly, creating regeneration areas.
IA-4	Scour Regime of Riparian and Channel Zones	1. 10-year flow on an annual basis 2. 5-year flow on an annual basis	Relative extent of wetland and riparian zones compared to depth for 5- and 10-year events; vegetation mapping at zonal boundaries for the w/o project condition.
IA-5	Inundation of Channel Margin Habitat	1. Time period=July 15-August 15 2. Highest stage sustained for 21 days for events that meet Criteria IA-3	Inundation of plant establishment area during later season that causes seedling drowning
IB-1	Rates of Channel Migration	1. 5-year flow on an annual basis 2. 1.5-year flow on an annual basis	Rate of habitat renewal; changes in shear force representative of changes in rate of channel migration
IB-2	Frequency of Flood Scour	1. 10-year flow on an annual basis 2. 5-year flow on an annual basis 3. Time period=July 15-August 15 4. Highest stage sustained for 21 days for events that meet Criteria IA-3	Distribution of flow depth for a given flow recurrence
IB-4	Rates of Germination Flows	1. Time period=April 1-July 15 2. Stage decline of <=0.88 feet/week 3. Return period <=10 years	Recurrence of overbank flow in seed release periods
Element II - Aquatic Ecosystem			
IIB-1	Spawning Habitat Abundance	1. Time period= February 1-May 31 2. Highest stage sustained for 21 days 3. Return period of x<=4 years	Suitable floodplain fish-spawning habitat
IIC-1	Rearing Habitat Abundance	1. Time period= December 1 - May 31 2. Highest stage sustained for 7 days 3. Return period<=4 years	Suitable floodplain fish-rearing habitat
IIC-3	Floodplain-channel Connectivity	1. Mean April and May flows; choose the larger 2. 3-year flow on an annual basis	Isolated floodplain habitat that may be possible fish stranding pools
IIE-1	Rate of Recruitment of Instream Woody Material	1. 1.5-year flow on an annual basis 2. 5-year flow on an annual basis 3. Average August flow 4. Highest stage sustained for 21 days for events that meet Criteria IA-3	Quality of channel gravels available for juvenile fish rearing; changes in shear stress representative of changes in rate of woody material recruitment; bankfull flow in relation to average low flow; presence of overhead cover along stream banks

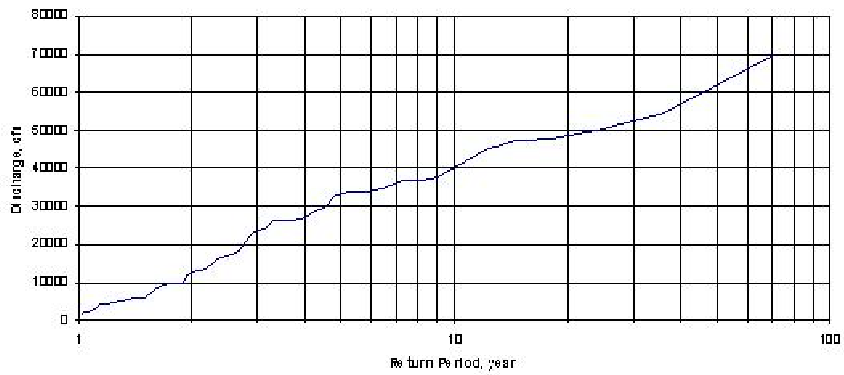

FIGURE 2 – SAMPLE EMPIRICAL FLOOD FREQUENCY CURVE

Category 2 – Monthly Average Flows

The average flow for a specific month in Category 2 can be estimated by taking the mean of daily flows of that month over the period of record of available gage data. Similarly, flow (stage)-duration-frequency relationships in Category 3 can be derived from daily flows within the given season for the period of record, as follows:

1. Sorting the moving minimum daily flows for the specified duration from the daily flows within the given season for each year.
2. Sorting the maximum moving minimum daily flow from the moving minimum daily flows for each year;
3. Generating an empirical flow-frequency curve for the maximum moving minimum daily flows from the entire data record;
4. Reading the flow magnitude off the empirical flow-frequency curve for the given frequency (return period).

Category 3 – Stage-Duration-Frequency

The ecosystem requirement IIB-1 is an example in Category 3. As shown in **Table 3**, IIB-1 requires the highest stage sustained for 21 days within the period of February 1 through May 31 of each year with a return period of 4 years. To develop this data, the minimum flow of each 21-day period is determined within the seasonal period for each year(i.e. the minimum flows of February 1 through February 21, February 2 through February 22, and so on through May 11 to May 31). Second, the maximum flow is determined from these minimum flows for each year. A flow-frequency curve can then developed based on these maximum flows within the entire period of record. **Figure 3** is a sample output file for ecosystem requirement IIB-1.

Figure 14

5. AQUATIC IIB-1 - SPAWNING HABITAT ABUNDANCE (EXCEPT OVERLAY WITH VEGETION MAPPING)

THE 4-YEAR SEASONAL 21-DAY FLOW IS 14800. CFS

(THE SEASON USED HERE IS: 2/ 1 --- 5/31)

THE SEASONAL FLOW-FREQUENCY CURVE USED HERE IS:

Exceedance	Discharge, cfs		Exceedance	Discharge, cfs
0.014	37900		0.514	5490
0.028	32800		0.528	5000
0.042	30800		0.542	4710
0.056	30700		0.556	4420
0.069	30100		0.569	4010
0.083	25400		0.583	3590
0.097	24800		0.597	3560
0.111	23800		0.611	3410
0.125	23700		0.625	3320
0.139	22900		0.639	3230
0.153	22600		0.653	3170
0.167	21100		0.667	2930
0.181	20900		0.681	2910
0.194	19900		0.694	2840
0.208	18800		0.708	2600
0.222	15200		0.722	2510
0.236	14900		0.736	2460
0.250	14800		0.75	2390
0.264	14700		0.764	2290
0.278	14400		0.778	2260
0.292	13400		0.792	2200
0.306	13300		0.806	2180
0.319	13200		0.819	2140
0.333	11600		0.833	2080
0.347	11600		0.847	2080
0.361	10700		0.861	1950
0.375	9850		0.875	1920
0.389	9820		0.889	1650
0.403	9260		0.903	1520
0.417	8340		0.917	1480
0.431	7810		0.931	1330
0.444	7710		0.944	1280
0.458	7590		0.958	1200
0.472	6780		0.972	945
0.486	6000		0.986	525
0.500	5730			

FIGURE 3 – SAMPLE OUTPUT DATA FOR ECOSYSTEM REQUIREMENT IIB-1

Category 4 – Stage Decline Rate

For Category 4, the statistical analysis requires additional work. Since the stage decline rate will vary from place to place within the study reach based on channel geometry, the statistical analysis cannot be performed using daily flows or stage records at gages. Instead, an index cross-section (or more, depending upon the size of the study reach) is selected to represent the entire study reach. A hydraulic model can be used to generate stage-discharge curves at the index cross-section. The gaged daily flows can then be converted into daily stages at the index cross-section using the stage-discharge curve generated by the hydraulic model. A statistical analysis is performed on the computed daily stages at the index cross-section, using the following steps:

1. Determine the time period within which the stage decline rate is to be examined: the time period is defined as the day of the highest peak to the end of the given season. For example, if the selected season for IA-3 were April 1 through July 15, the time period would be from the day with the highest stage within the season to July 15. As peak stages occur on different days in different seasons, the time period varies accordingly.
2. Determine the dates used to determine the stage decline rate: Given the time period from developed in the previous step, specific dates are determined backward from the end of the time period. For example, if the time interval for IA-3 was specified as weekly the dates would be set at July 15 (end of period), July 8, July 1, June 24, and so on with the last one on the peak stage day or less than 7 days after the peak stage day.
3. Determine the stage decline rate: the stage decline rate is computed as inches per week (or inches per day) backward starting from the end of the time period and compared to a threshold decline rate (0.88 ft/week was used for IA-3 in preliminary studies). If the computed decline rate is smaller than the threshold, the minimum daily

flow is sorted out from that week and the process continues for the next seven-day period. Otherwise, the process is stopped.

4. Sort out the maximum weekly minimum flow from weekly minimum flows obtained from the previous step.
5. Repeat steps 1 through 4 for each year in the data record to get an annual sequence of maximum weekly minimum flows.
6. Derive an empirical frequency curve for the annual sequence of maximum weekly minimum flows from step 5.
7. Read the flow magnitude from the empirical frequency curve with the specified frequency or return period called for by the ecosystem requirement element. This flow value is then associated with the year in which it occurred and that year's flow records are used for Category 5 calculations.

Figure 4 is a sample output file for the ecosystem requirement IA-3.

2. TERRESTRIAL IA-3 - FLOOD EVENTS SUITABLE FOR PLANT ESTABLISHMENT

THE 10.0-YEAR FLOW IS 2924 .

THE YEAR 1957 HAS AN EQUIVELENT FLOW OF 10.0-YEAR FOR THE SEASON OF 4/ 1 -- 7/15

SEASONAL 7-DAY FLOW W/ STAGE DECLINE RATE < 0.55 FT/(7-DAY) -- FREQUENCY CURVE
AT THE INDEX LOCATION IS:

Exceedence	Discharge, cfs	Exceedence	Discharge, cfs
0.014	29700	0.514	955
0.028	15300	0.528	940
0.042	11200	0.542	935
0.056	3550	0.556	915
0.069	3540	0.569	910
0.083	3440	0.583	895
0.097	2940	0.597	840
0.111	2860	0.611	834
0.125	2650	0.625	776
0.139	2640	0.639	735
0.153	2620	0.653	648
0.167	2430	0.667	595
0.181	2020	0.681	590
0.194	2010	0.694	424
0.208	1910	0.708	406
0.222	1910	0.722	298
0.236	1910	0.736	0
0.250	1900	0.750	0
0.264	1840	0.764	0
0.278	1820	0.778	0
0.292	1780	0.792	0
0.306	1540	0.806	0
0.319	1480	0.819	0
0.333	1470	0.833	0
0.347	1450	0.847	0
0.361	1420	0.861	0
0.375	1290	0.875	0
0.389	1190	0.889	0
0.403	1150	0.903	0
0.417	1140	0.917	0
0.431	1140	0.931	0
0.444	1120	0.944	0
0.458	1100	0.958	0
0.472	1100	0.972	0
0.486	1070	0.986	0
0.500	970		

FIGURE 4 – SAMPLE OUTPUT DATA FOR ECOSYSTEM REQUIREMENT IA-3

Category 5 – Highest Sustained Stage

Requirements in Category 5 are similar to those in Category 3 except that only the seasonal daily flows of a specific year, instead of the entire record period, are used to derive the highest stage sustained for 21-day period. The "specific year" used here is defined as the year that the seasonal daily flow (stage) record meets the requirement of IA-3.

EFM Statistical Analysis FORTRAN Software Package

Because there is no existing computer software package that can meet the needs of the statistical hydrology analysis in the EFM model, a customized computer software package was developed in order to apply this model efficiently to multiple study areas within the

Sacramento and San Joaquin River basins. The FORTRAN programming language was used for this purpose, and the analysis procedure developed above was coded into the program. The FORTRAN program reads daily flow gage records and stage records at an index location from a text input file. From an input command screen, users select the ecosystem functions to be evaluated and their corresponding requirements, such as a season's beginning and ending dates, flow or stage duration, stage decline rates, and so on. The designed flexibility of data and command input enables the program to be used in not only the Sacramento and San Joaquin River basins, but in virtually any river basin provided the ecosystem functions specific to the study basins are properly identified. The results of the computer program are provided in text output files for each of the ecosystem functions.

The FORTRAN source code, sample input data and command files, and eleven output files of this EFM software package are included in attachments to this appendix. The FORTRAN program currently runs in DOS mode. However, a Windows' Graphical User Interface (GUI) is being developed by the Hydrologic Engineering Center of the Army Corps of Engineers.

HYDRAULIC ANALYSIS

The hydraulic analysis evaluates the hydraulic responses of the various discharges estimated in the hydrologic analysis. Calculated discharges are input into a hydraulic model, such as HEC-RAS, to obtain computed water surface elevations, shear stresses, and velocities. The hydraulic analysis for the EFM is performed on a reach-by-reach basis, unlike the system-wide UNET models developed for the Comprehensive Study. Because the EFM evaluates localized hydraulic conditions, it needs more detailed channel and floodplain geometry information than is currently available in the UNET models, which have cross sections spaced at one-quarter mile increments.

Preliminary EFM evaluations utilized HEC-GeoRAS to create geo-referenced cross-sections and process hydraulic results exported from HEC-RAS for visualization in ArcView. HEC-GeoRAS is an extension to the GIS software ArcView that allows the exchange of information between ArcView and HEC-RAS. HEC-GeoRAS can be used to create HEC-RAS models using geographic-based information (topography or digital elevation models) stored in a GIS or CAD environment. It can also be used to export model data from HEC-RAS, such as water surface elevations or inundation areas, for display or evaluation in a GIS environment. Other hydraulic models and GIS packages could also be used to perform the hydraulic analysis step of the EFM.

EFM PILOT STUDIES

Two pilot studies have been completed, one on the San Joaquin River near Vernalis and the other on the Sacramento River near Princeton. These studies are described below.

San Joaquin River near Vernalis

A pilot study has been completed which applied ecologic, hydrologic, hydraulic, and GIS components of the EFM to a 13-mile reach of the lower San Joaquin River immediately downstream of the Stanislaus River. The reach was selected for the following reasons: 1) the river creates no significant backwater effect in the reach; 2) the reach has a relatively wide floodplain within the levee on one side and naturally higher ground on the other side which makes it easier to differentiate inundation areas with different flows; and 3) availability of an USGS gage with a daily flow record long enough (Water Year 1930-2000) for a statistical analysis. The study area is illustrated in **Figure 5**.

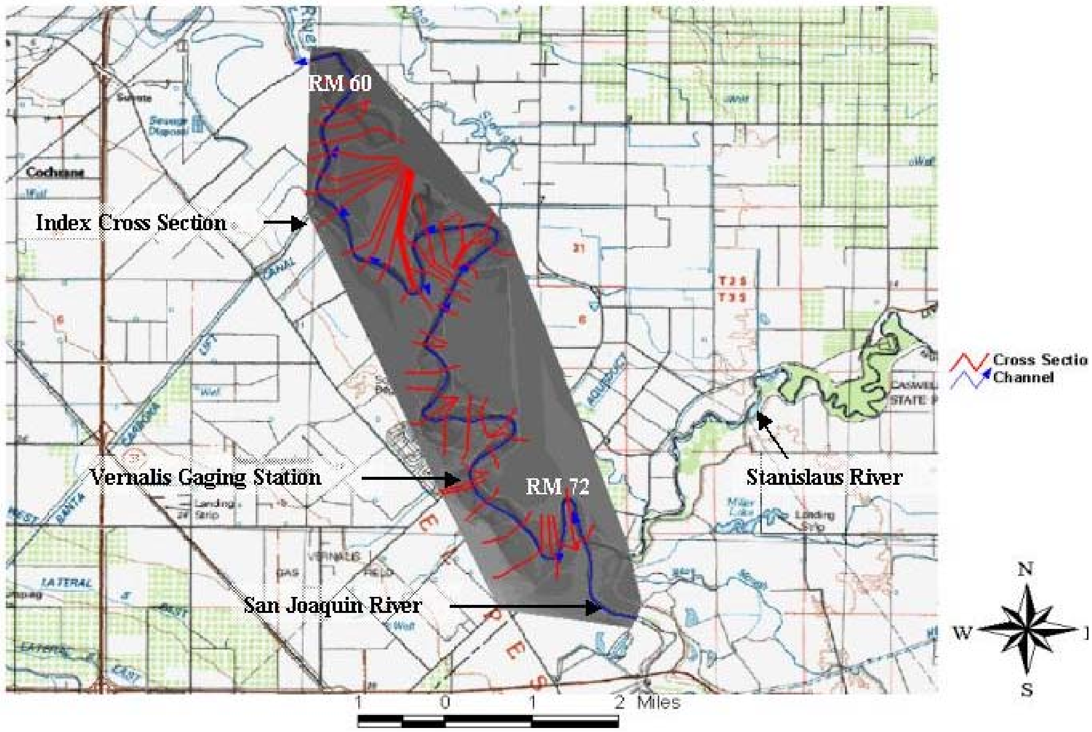

FIGURE 5 – SAN JOAQUIN EFM PILOT STUDY AREA

The pilot study mainly focused on the hydrologic and hydraulic analysis and GIS output creation (Steps 2, 3, and 4) using the quantified ecosystem relationships from Step 1 as the input. Ecologists and geomorphologists will then work together to interpret what the result means from the GIS maps produced in Step 4.

The procedure and methodology used and sample results in each of Steps 2, 3, and 4 are discussed in more detail in the following sections.

Ecological Analysis

The ecological relationships discussed in the previous section were used as the ecological input to the hydrologic and GIS analysis steps.

Hydrologic Analysis

A USGS gage on the San Joaquin River near Vernalis is located within the study reach. The gage has a continuous daily flow record from water year 1930 through 2000, which can be used in the statistical analysis. This gage was used to develop the five categories of hydrologic data needed for the EFM.

Since numerous reservoirs were built upstream from the study reach during the period of record, a homogeneity test of stream flow was conducted to see if there were any significant changes in the flow pattern. If the test shows any significant change in flow pattern, separate statistical analyses would need to be conducted on different portions of the stream flow record, which may represent different phases of water resources development in the basin. The homogeneity test was performed on a monthly basis. **Figures 6** through **17** are flow-mass curves for the months of January through December for the period of record. In general, the curve slopes were consistent. However, there were visible breaks in slope for a few of the tested months (i.e., April and May in the mid-1940s). This may be related to the construction or enlargement of surface water reservoirs in the San Joaquin Basin above Vernalis. For the purposes of this pilot study, these changes have little effect on criteria results because 1) a small portion of the period of record is affected and 2) elevated slopes in the 1930's have more influence on the upper end (rare events) of an empirical frequency curve while the EFM criteria focused on frequent events. Therefore, the entire daily flow record (1930-2000) was deemed generally consistent and used in the statistical analysis. In future EFM applications in the lower San Joaquin Basin, especially for those associated with planning changes to existing channel geometry, flows prior to 1944 should be used with caution.

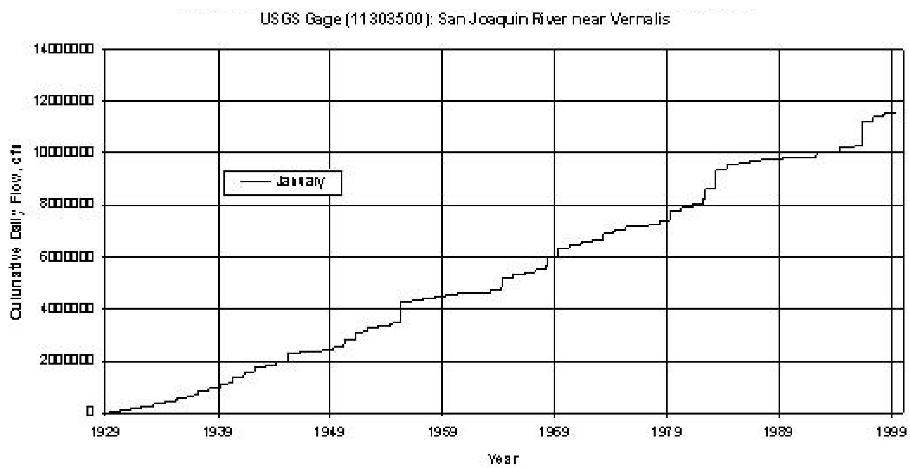

FIGURE 6 – MASS DIAGRAM ANALYSIS OF JANUARY DAILY FLOWS

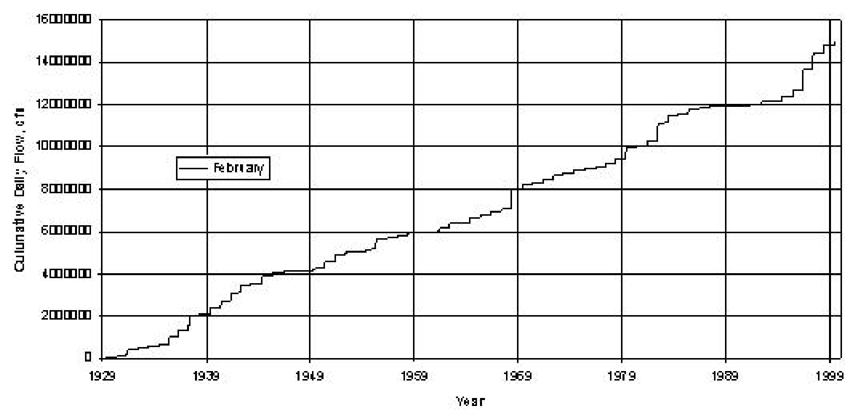

FIGURE 7 – MASS DIAGRAM ANALYSIS OF FEBRUARY DAILY FLOWS

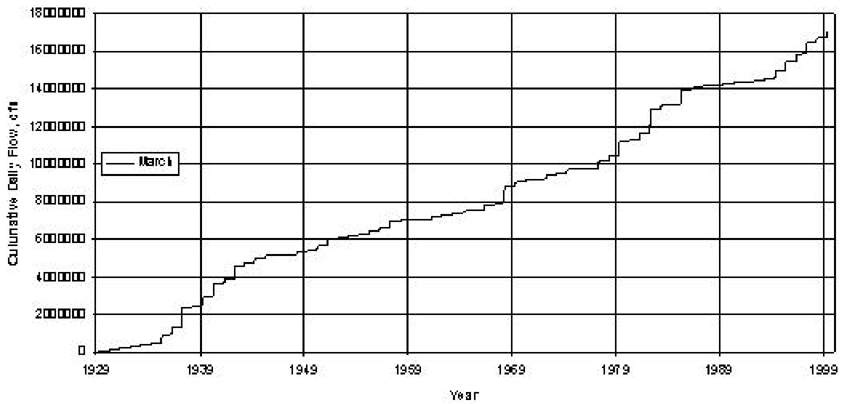

FIGURE 8 – MASS DIAGRAM ANALYSIS OF MARCH DAILY FLOWS

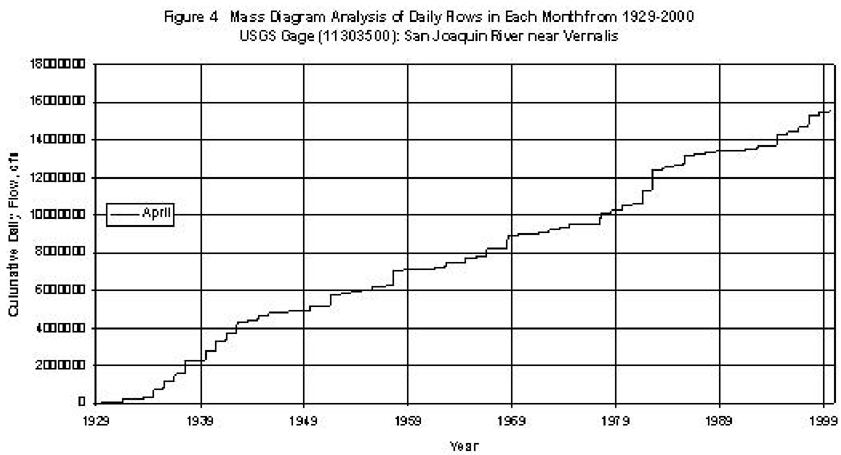

FIGURE 9 – MASS DIAGRAM ANALYSIS OF APRIL DAILY FLOWS

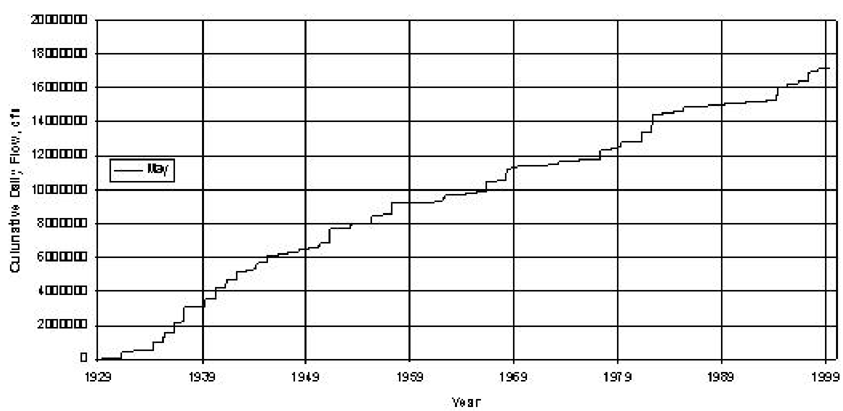

FIGURE 10 – MASS DIAGRAM ANALYSIS OF MAY DAILY FLOWS

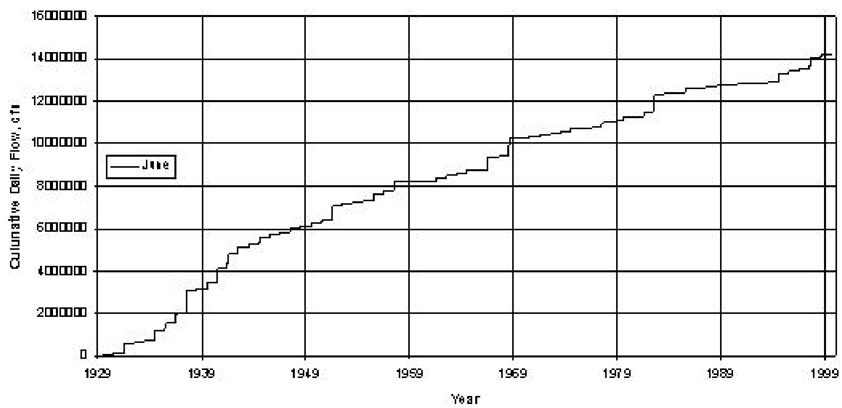

FIGURE 11 – MASS DIAGRAM ANALYSIS OF JUNE DAILY FLOWS

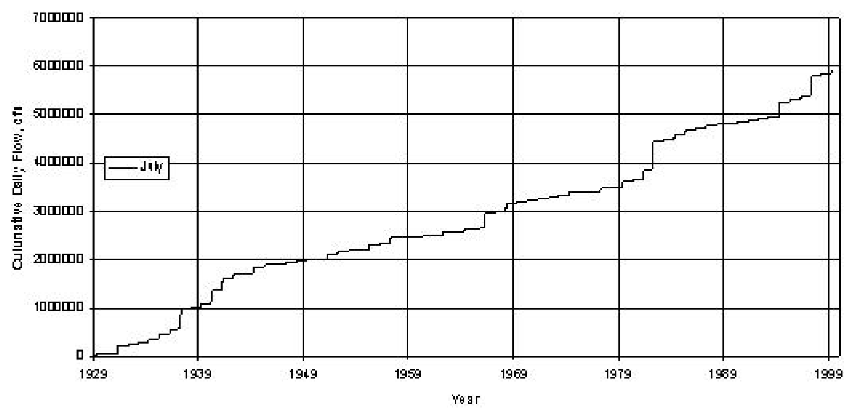

FIGURE 12 – MASS DIAGRAM ANALYSIS OF JULY DAILY FLOWS

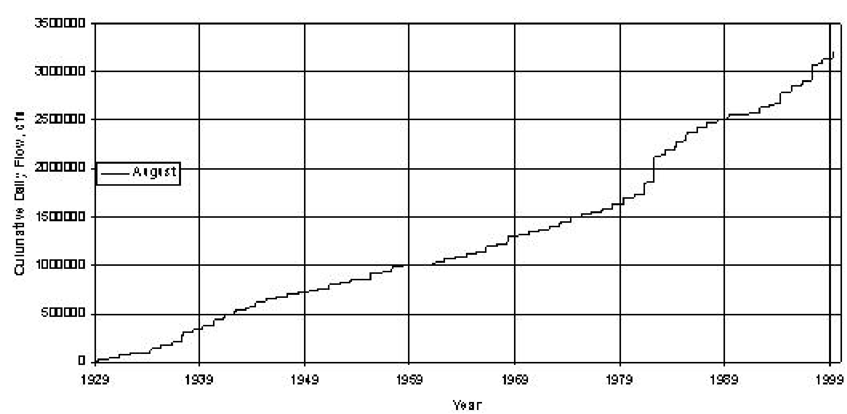

FIGURE 13 – MASS DIAGRAM ANALYSIS OF AUGUST DAILY FLOWS

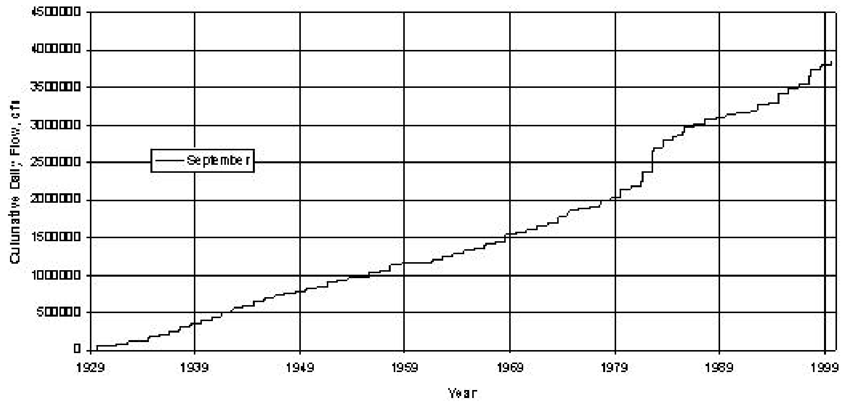

FIGURE 14 – MASS DIAGRAM ANALYSIS OF SEPTEMBER DAILY FLOWS

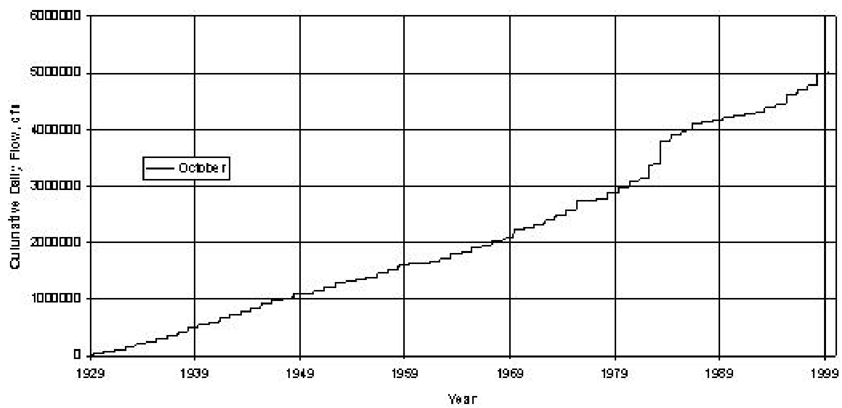

FIGURE 15 – MASS DIAGRAM ANALYSIS OF OCTOBER DAILY FLOWS

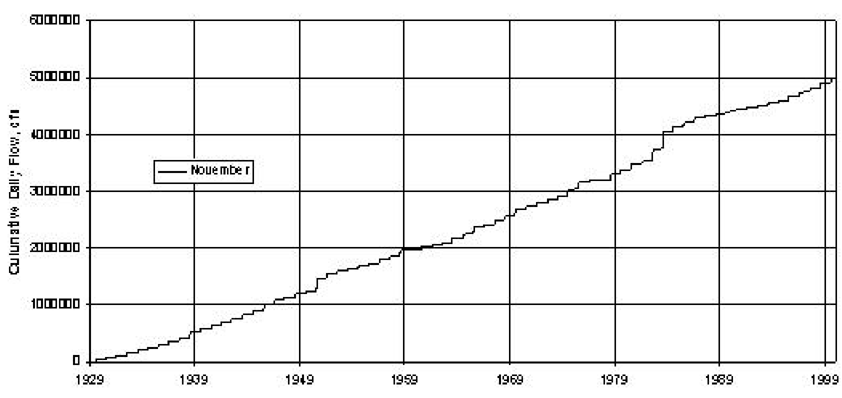

FIGURE 16 – MASS DIAGRAM ANALYSIS OF NOVEMBER DAILY FLOWS

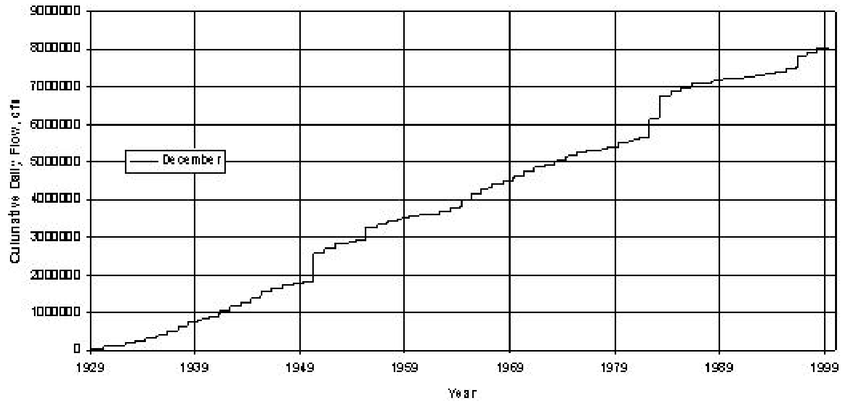

FIGURE 17 – MASS DIAGRAM ANALYSIS OF DECEMBER DAILY FLOWS

An empirical peak flood-frequency curve was developed from daily flow data collected at the USGS gage at Vernalis for the entire period of record (1930-2000), shown in **Figure 18**. This provided Category 1 flood frequency input.

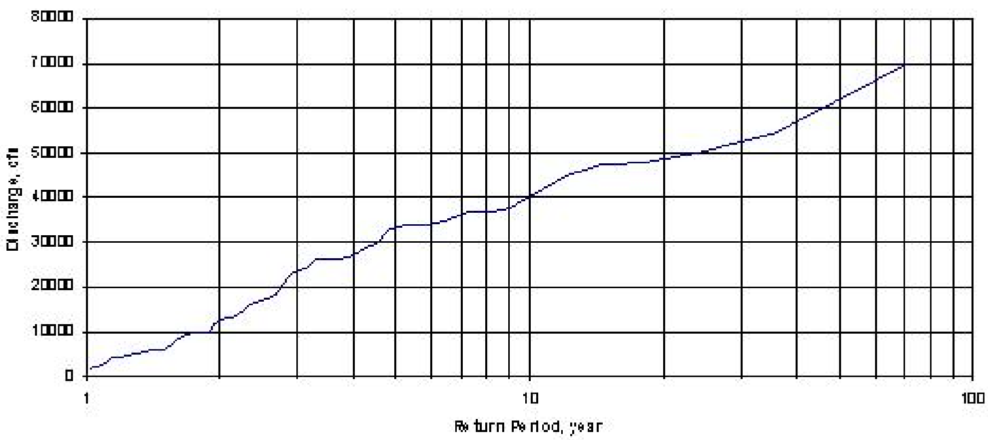

FIGURE 18 – EMPIRICAL FLOOD FREQUENCY CURVE FOR SAN JOAQUIN RIVER NEAR VERNALIS

Monthly average flow data for Category 2 was estimated by taking the mean of the daily flows of that month over the entire period of record (Water Year 1930-2000), and flow (stage)-duration-frequency relationships were derived from daily flows within the given season for the entire period of record. Category 3 flows were derived from daily flows within the given season for the period of record. For Category 4 flows, the selected season for IA-3 was April 1 through July 15 and the time period was from the day with the highest stage within the season to July 15.

Table 4 is the summary of results of this statistical analysis for the pilot study reach using the FORTRAN program developed for the EFM and the procedures previously discussed.

TABLE 4
STATISTICAL FLOW ANALYSIS FOR VERNALIS PILOT STUDY

Sub-Element	Estimated Flow, cfs
1.5-year flow on an annual basis	6,000
3-year flow on an annual basis	23,600
5-year flow on an annual basis	33,340
10-year flow on an annual basis	40,220
IA-2, Average August flow	1,458
IA-3, 0.88ft/wk, Apr 1-Jul 15, 10-year	2,924
IA-5, 21-day, Jul 15-Aug 15, 1987. (Water Year 1987 - from IA-3)	1,420
IIB-1, 21-day, Feb 1-May 31, 4-year	14,800
IIC-1, 7-day, Dec 1-May 31, 4-year	24,400
IIC-3, Maximum of mean April and May flows	7,855
IIE-1, 21-day, Jul15-Sep30, 10-year	3,360

Estimates are based on the Water Year 1930-2000 daily flow record at USGS Gage – San Joaquin River near Vernalis.

Hydraulic Analysis

A steady-state flow regime was assumed for all the hydraulic calculations. This assumption provided that the stage-duration relationships at any location within the study reach could be derived from the representative gage flow record. The stages could then be calculated by simulating the estimated flows in a hydraulic model of the study reach.

A HEC-RAS hydraulic model was developed for the 13-mile study reach. HEC-GeoRAS was used to facilitate model development, providing a means of extracting geometric data (channel cross sections) from a three-dimensional surface-topography model or TIN (triangulated irregular network). To cover the entire study area, two-foot contour topography within the stream channel (developed previously by the Comprehensive Study) was combined with USGS 30-meter digital elevation models (DEM's) to construct the TIN. HEC-GeoRAS was used to extract geo-referenced channel cross-sections and other parameters from the TIN for import into HEC-RAS. The HEC-RAS model was calibrated to the USGS rating curve at the San Joaquin River near Vernalis gage (USGS Gage #: 11303500). Water surface elevations and flow velocities were calculated in HEC-RAS and the information was exported back to HEC-GeoRAS for floodplain and velocity mapping. Refer to the USACE *HEC-GeoRAS User's Manual* (HEC, 2000) for a more complete description of this hydraulic modeling tool.

To provide boundary conditions for the geo-referenced HEC-RAS model, a HEC-RAS model developed previously for the Comprehensive Study (Channel Capacity Analysis of the San Joaquin River Systems, Ayres and Associates, February 2001) was selected. This model extends approximately 7 miles downstream from the study reach and was originally calibrated to the 1997 flood. However, more frequent floods than the 1997 event are of concern to the EFM. Therefore, the model was re-calibrated to lower flows, using the USGS rating curve at the San Joaquin River near Vernalis gage, before it was used to provide the starting water surface elevations for the geo-referenced HEC-RAS model.

The HEC-RAS model was used to generate a stage-discharge rating curve at the selected index cross-section. The generated stage-discharge rating curve at the index cross-section was then used to convert gage daily flows to stages, with which the statistical analysis was performed for ecosystem functions 1A-3, 1A-5, 1B-2, 1B-4, and 2E-1.

The calibrated HEC-RAS model represents the existing or base condition model. An HEC-RAS model describing the hypothetical levee setback condition was constructed by modifying cross-section geometry in the existing condition model. Discharges estimated in the hydrologic analysis were used as input to the geo-referenced HEC-RAS models for both existing and levee setback conditions. Existing condition model runs indicated that only flows with a 1 in 3 chance of occurring in any year or larger can get out of channel; therefore, levee realignment simulations were only performed for events of this magnitude or greater. Model results were exported to HEC-GeoRAS and ArcView for comparison and visualization.

GIS Analysis

In order to graphically display the flood inundation and flow velocity distribution, the computed water surface elevations and flow velocities from the HEC-RAS model were exported into HEC-GeoRAS to construct water surface and velocity TIN's. The water surface and velocity data were then compared with terrain data by HEC-GeoRAS to delineate floodplains and flow velocity distributions. The floodplains generated by the various flows from the hydrologic analysis were overlain with substrate characteristics, such as soil distribution maps, to predict zones that would be suitable for different ecosystem functions. **Figures 19 through 24** provide examples of the GIS maps. **Figure 19** shows the general vicinity of the study area, **Figures 20 through 23** are floodplains from different estimated flows, and **Figure 24** the 5-year floodplain with levee setback condition.

FIGURE 19 – 1998 AERIAL PHOTOGRAPH OF SAN JOAQUIN PILOT STUDY AREA

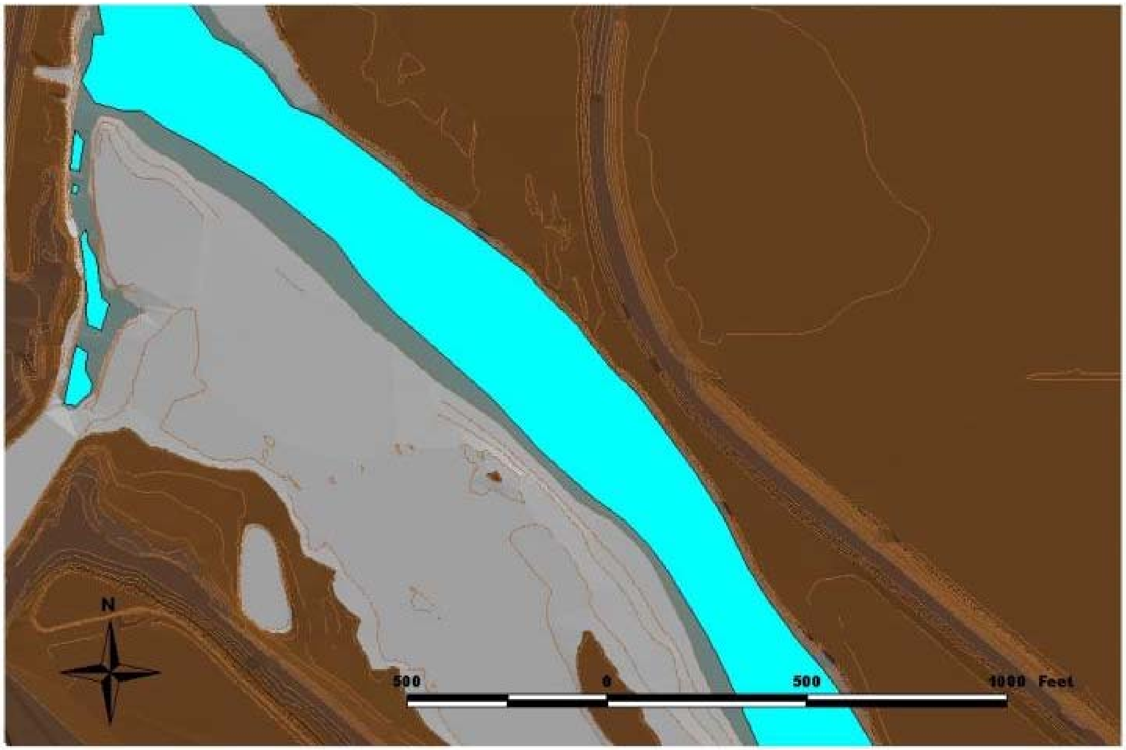

FIGURE 20 – AVERAGE AUGUST WATER SURFACE ELEVATION (1458 CFS)

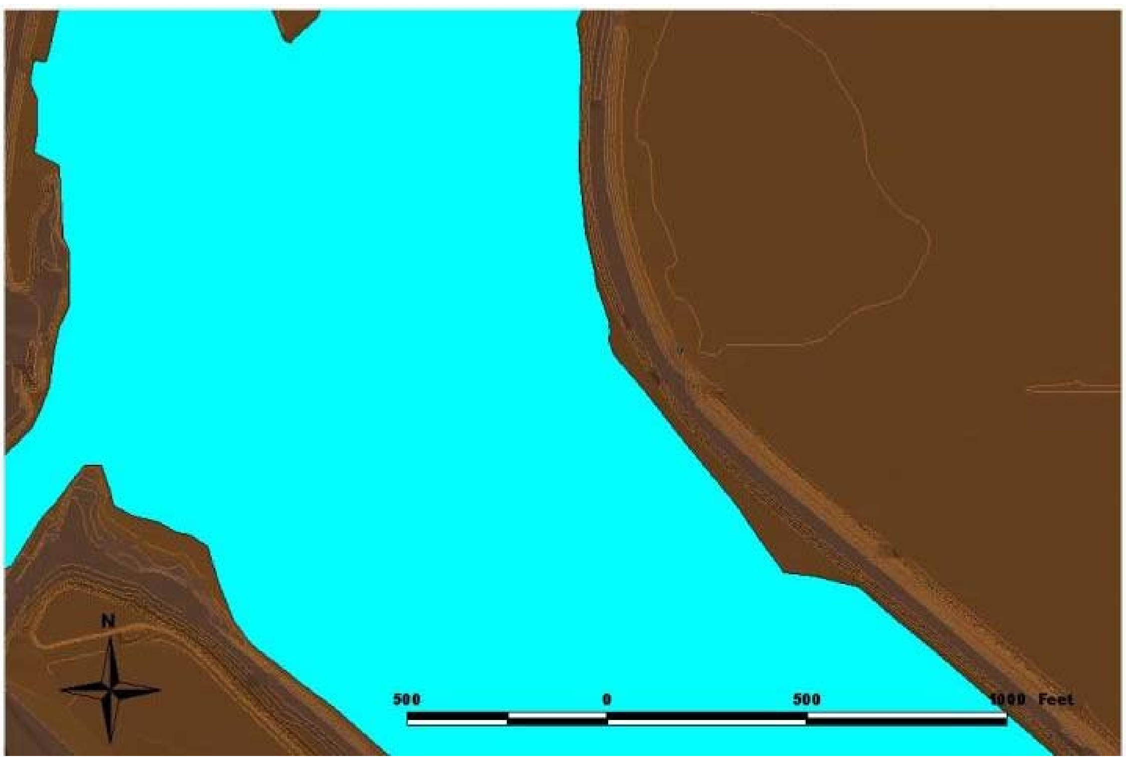

FIGURE 21 – WATER SURFACE ELEVATION OF 3-YEAR FLOW (23,600 CFS)

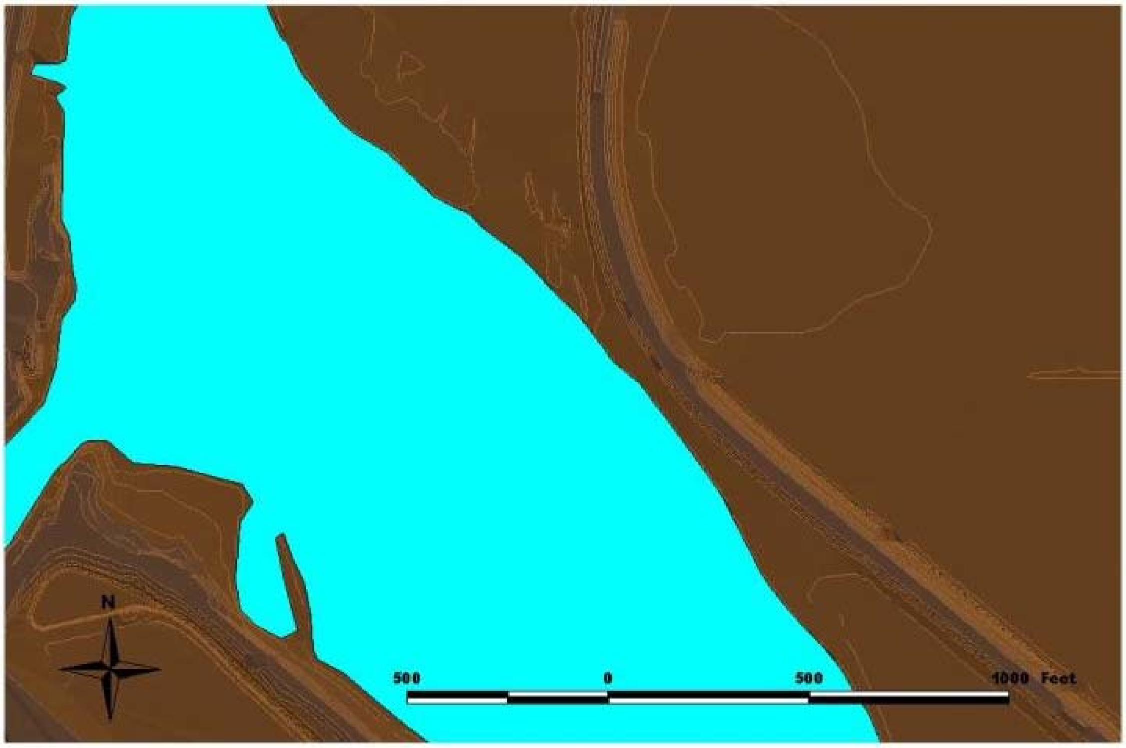

FIGURE 22 – FLOW MEETING EFM IIB-1 CRITERIA (14,800 CFS)

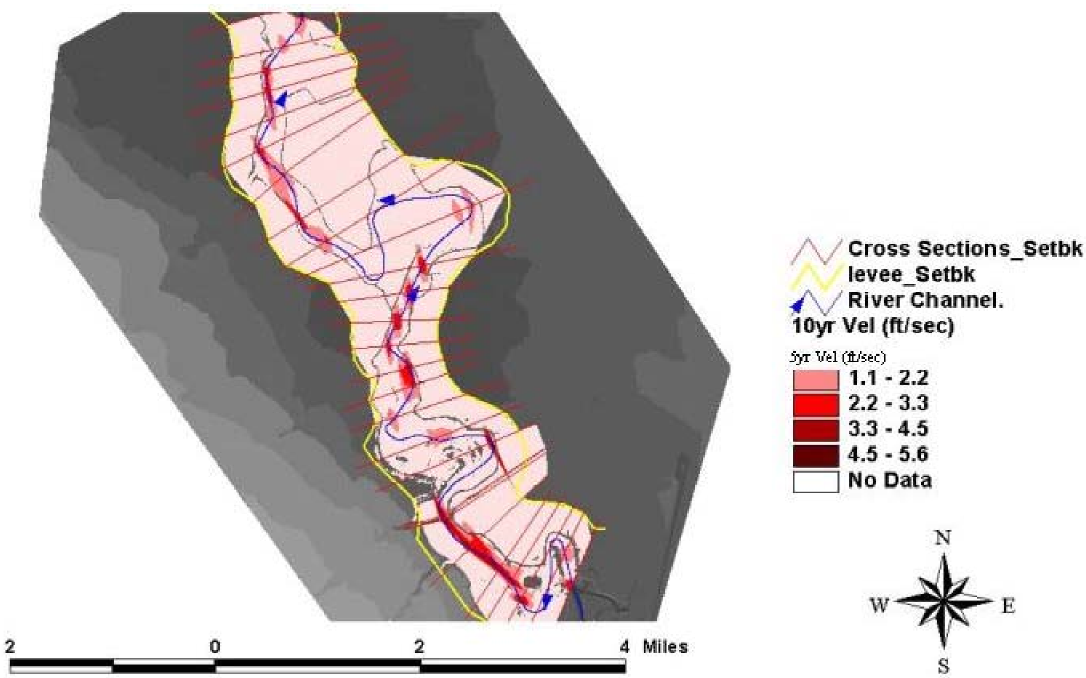

FIGURE 23 – 20% PROBABILITY FLOODPLAIN WITH HYPOTHETICAL LEVEE REALIGNMENT (33,340 CFS)

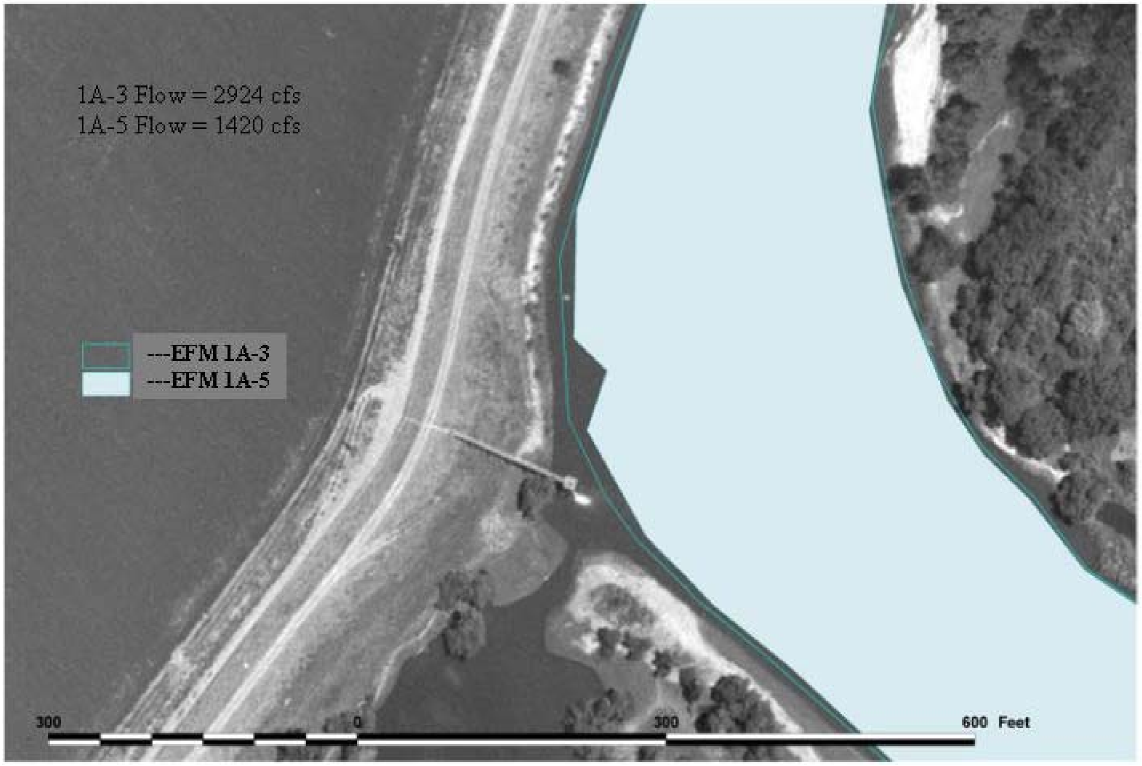

FIGURE 24 – POTENTIAL COTTONWOOD RECRUITMENT ZONES

Ecological Interpretation

Ecologists evaluate and interpret the various features displayed on **Figures 19 through 24** and other model output and make comments or recommendations on the proposed flood management measures and/or ecosystem restoration features. For example, **Figure 24** is a GIS map showing the aerial extent of flood events suitable for plant establishment (Ecosystem Function IA-3) overlaid by the inundation of channel margin habitat (Ecosystem Function IA-5). The area of IA-3 that is not overlapped by that of IA-5 may be considered the zone suitable for the cottonwood recruitment.

Preliminary Results and Field Verification

A statistical analysis of the model algorithms and hydraulic data for the 1997 flood season was completed. Mapping of analysis results indicates that there are several locations in the pilot reach that should support riparian vegetation. These model outputs were field-verified for accuracy during a visit to the pilot reach. The areas projected to have riparian vegetation by the EFM did in fact have willow and cottonwood seedlings of the appropriate age class to have sprouted following the 1997 flood season.

The study's development team evaluated the model's performance by comparing EFM-predicted vegetation establishment zones with field surveys of vegetation establishment sites. Staff canoed the lower San Joaquin River to locate sites with riparian seedlings and sites without seedlings and visited sites where land access was feasible. Staff members were able to use plant morphological characteristics to discriminate between 0-, 1-, 2-, and 2+-year seedlings. Team members found over fifteen sites with riparian seedlings; all sites that had seedlings were within EFM-predicted establishment areas. No seedlings were found in areas that were outside EFM-predicted establishment areas. However, since the previous winter had relatively low flows, the extent of the seedling establishment areas was limited. The Study's staff will conduct additional analyses of the San Joaquin data and conduct further tests at other locations. The main criteria requiring further testing include the stage recession rate function 1A3 for Flood Events Suitable for Plant Establishment and the Groundwater Surface Depth (1A2) function.

Sacramento River near Princeton

The Princeton pilot study involved the evaluation of a hypothetical levee realignment that would re-connect approximately 480 acres of floodplain land to the Sacramento River. The Princeton site was selected for the following reasons: 1) there is no significant backwater effect in the reach; 2) the left bank levee necks-down and constricts the river near the town of Princeton, offering a logical location to straighten the levee; 3) a nearby USGS gage provided a daily flow record the was long enough for a statistical analysis. The evaluation was performed in a similar manner as described for the San Joaquin River analysis. The hydrologic and hydraulic analyses used gage data from the Butte City gage based on Water Years 1939 to 1995.

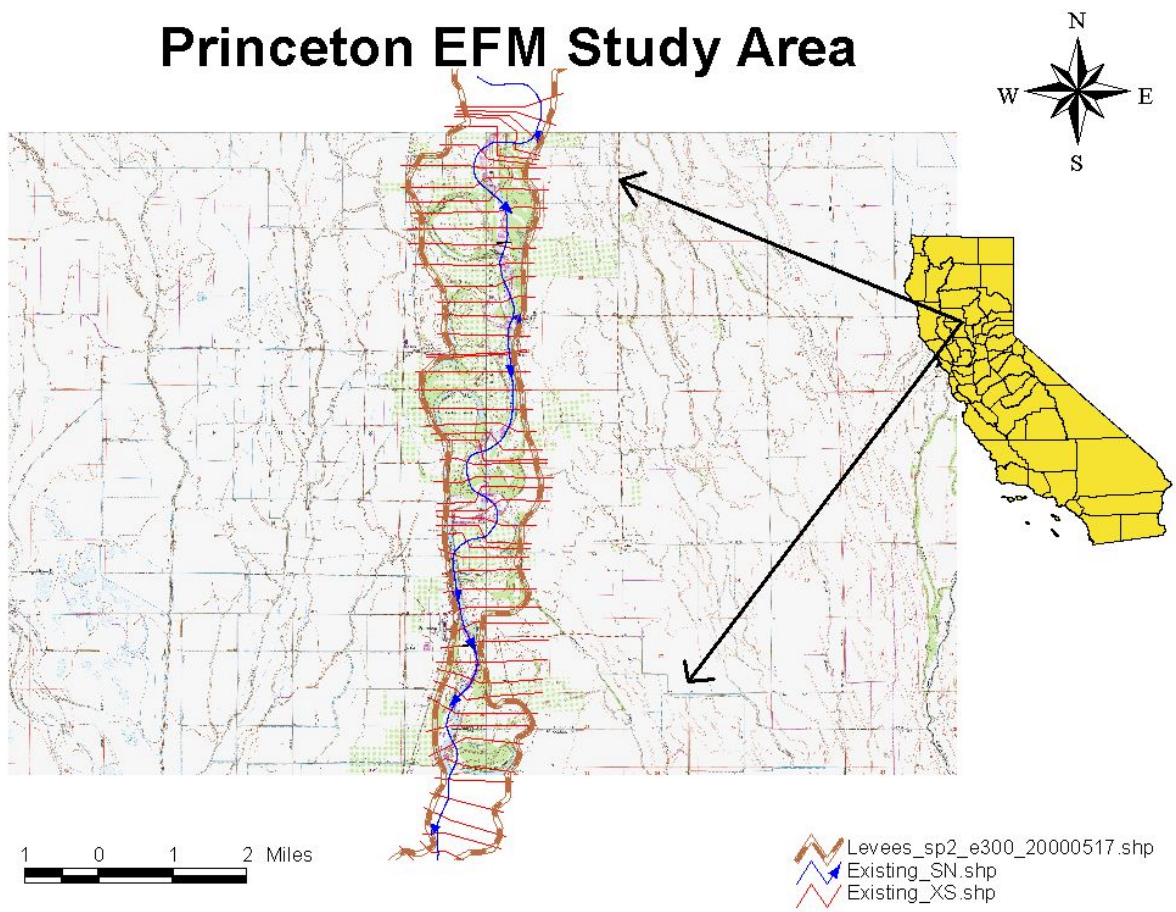

FIGURE 25 - PRINCETON PILOT STUDY AREA

TABLE 5
STATISTICAL FLOW ANALYSIS FOR PRINCETON PILOT STUDY

Sub-Element	Est. Flow (cfs)
IA-2, Average August flow	7,559
IA-5, 21-day, Jul 15-Aug 15 - Water Year 1987 from IA-3	79,140
IIE-1, 21-day, Jul15-Sep30, 10-year	10,500
IA-3, 0.88ft/wk, Apr 1-Jul 15, 10-year	10,960
IIC-3, Maximum of mean April and May flows	14,784
IIB-1, 21-day, Feb 1-May 31, 4-year	24,150
1.5-year flow on an annual basis	57,500
IIC-1, 7-day, Dec 1-May 31, 4-year	63,200
3-year flow on an annual basis	100,333
5-year flow on an annual basis	128,200
10-year flow on an annual basis	146,200

Preliminary Results

Mapped results indicate that a portion of the 480-acre increase in floodplain (reconnected to the river by a hypothetical levee realignment) would be flooded about every 2 years. Water surface elevations were decreased by about 2.5 inches for an event with a 1 in 10 chance of occurrence in any year. A large portion of the new floodplain area would be suitable for floodplain fish-rearing habitat. Because the flows suitable for willow and cotton wood recruitment are contained within the channel, the EFM suggests that the spatial extent of riparian vegetation will not improve initially as a result of the levee setback. However, the floodplain would likely erode to the east with a corresponding point bar formation occurring on the west bank of the river. Additional analysis will be conducted to identify potential scour zones in the overbank floodplain to determine whether fish would become stranded in the floodplain and how the area may become recontoured in the future. Areas identified by the model as being potential stranding areas will be field verified in the near future. **Figures 26** and **27** illustrate potential Willow-Cottonwood recruitment zones and potential floodplain rearing habitat identified by the EFM.

One unforeseen problem identified in this test involved the problems dealing with a river system that is perched above the adjacent floodplain land, or above the potentially realigned levee system. In reaches of the river where the vegetative recruitment flows would reach the new overbank floodplain, there is no easy method of determining how the landside slope would respond during the periods having drawdown rates within those required for recruitment. This will also be evaluated further during future trials.

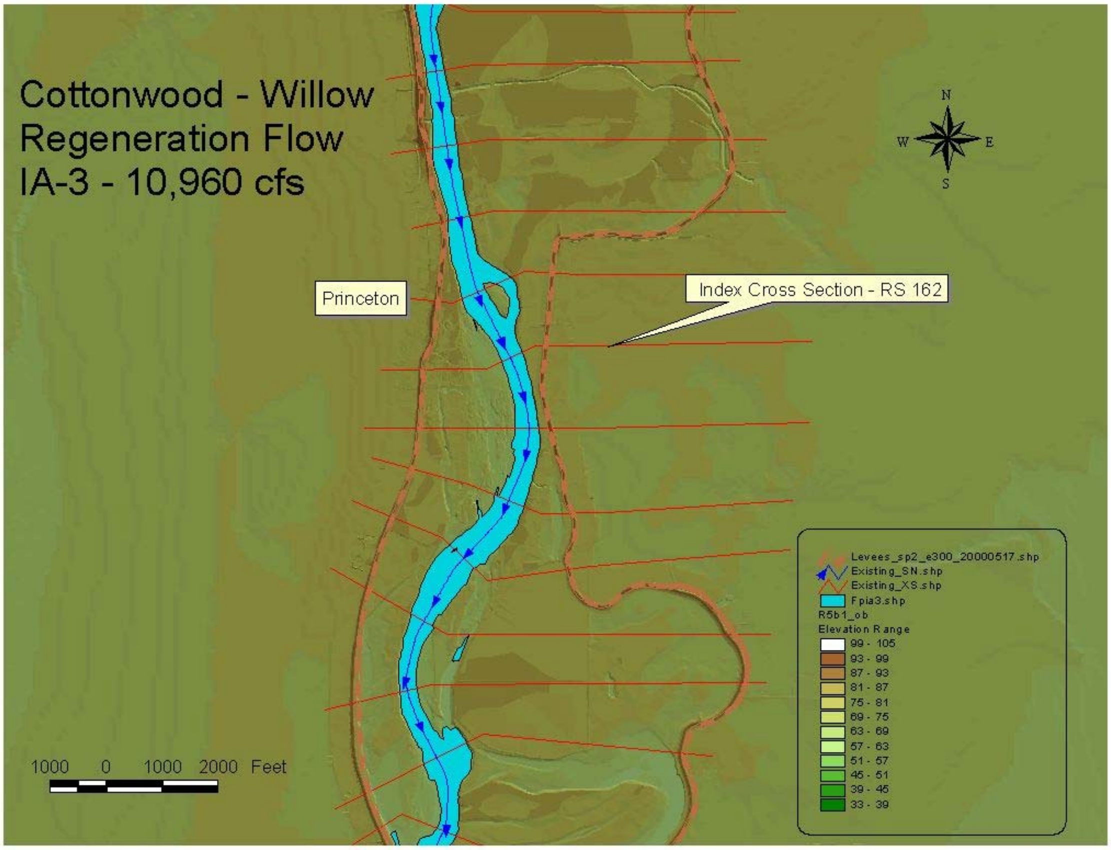

FIGURE 26 - POTENTIAL WILLOW-COTTONWOOD RECRUITMENT ZONE

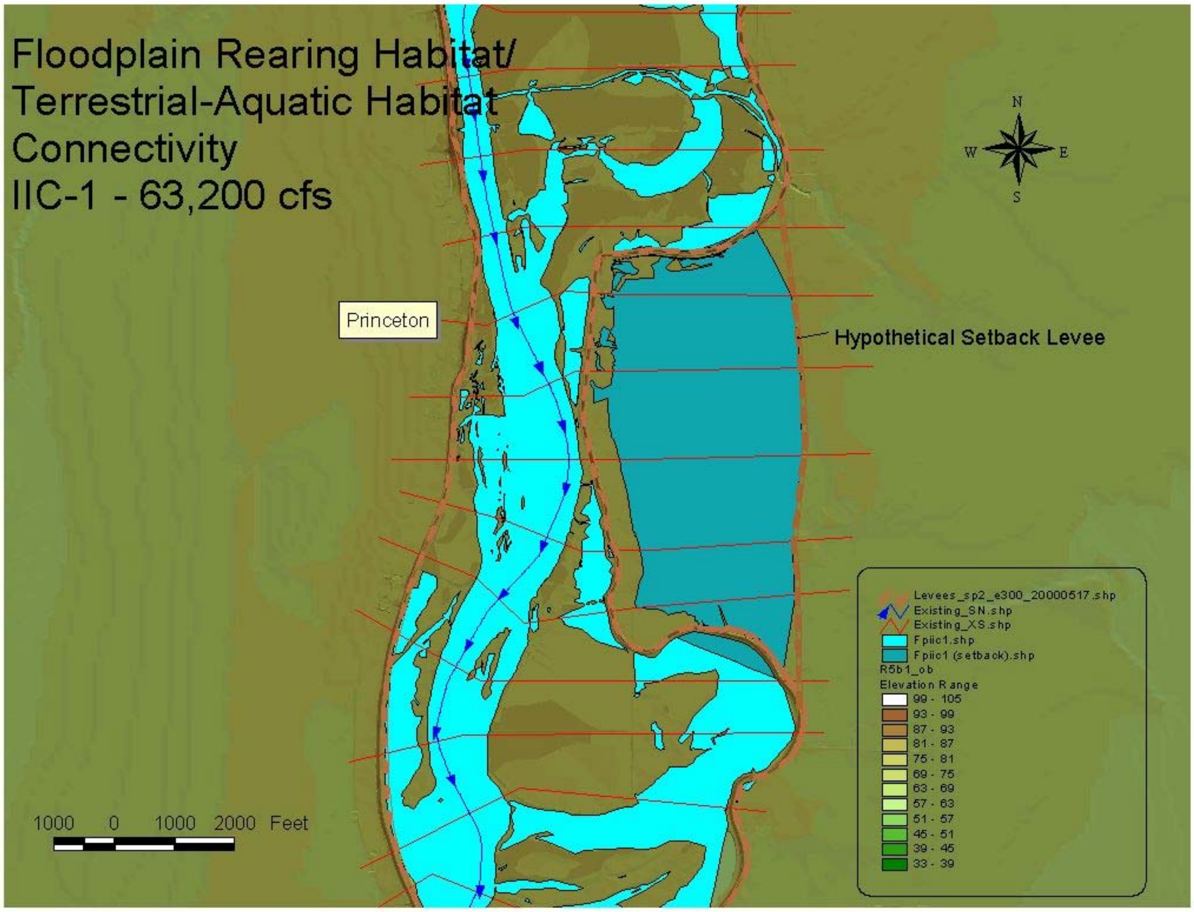

FIGURE 27 – POTENTIAL FLOODPLAIN REARING HABITAT

REFERENCES

Jones & Stokes Associates, 2000. *Final Functional Relationships for the Ecosystem Functions Model*, Prepared for Sacramento-San Joaquin Rivers Basin Comprehensive Study Team, U.S. Army Corps of Engineers, Sacramento District, Davis, CA, December.

Hydrologic Engineering Center, 2001. *HEC-RAS River Analysis System*, User's Manual, U.S. Army Corps of Engineers, Davis, CA, January.

Hydrologic Engineering Center, 2000. *HEC-GeoRAS ArcView*, User's Manual, U.S. Army Corps of Engineers, Davis, CA, April.

ATTACHMENT G1

EFM STATISTICAL ANALYSIS SOFTWARE PACKAGE FORTRAN SOURCE CODE

```
      PROGRAM EFM
C     EFM VERSION 1.1
C     THIS PROGRAM IS TO DO THE STATISTICAL ANALYSIS FOR THE EFM MODEL.
C     AUTHOR: HONGBING YIN
C     COE AND DWR SACRAMENTO AND SAN JOAQUIN RIVERS COMPREHENSIVE STUDY
TEAM
C     OCTOBER, 2001
C
      INTEGER IDAY(37000),IMONTH(37000),JDATE,IYEAR(37000),
     +        NTOTAL,IY(100),YEAR(100),JDAY(36799),BMONTH1,
     +        BDAY1,EMONTH1,EDAY1,JDY(100),THEYEAR,BMONTH,
     +        BDAY,EMONTH,EDAY,BDATE(100),EDATE(100),VERYB
      REAL STAGE(37000),FLOW(37000),FREQ1,FREQ2,RY1,RY2,
     +     YMAXQ(100),YMAXQ1(366),SEASONQ(366),FREQS(100)
      CHARACTER FILEIN*12
C
      OPEN(9,FILE='EFMINPUT.DAT',STATUS='OLD')
      READ(9,11) FILEIN
11    FORMAT(/A12//)
      OPEN(5,FILE=FILEIN,STATUS='OLD')
      I=1
1100  READ(5,21,END=1005) IMONTH(I),IDAY(I),IYEAR(I),FLOW(I),STAGE(I)
      I=I+1
      GO TO 1100
1005  NTOTAL=I-1
21    FORMAT(I2,1X,I2,1X,I4,1X,F8.1,F8.2)
      CALL DAYADJ(IMONTH(1),IDAY(1),IYEAR(1),VERYB)
      DO 500 I=1,NTOTAL
        CALL DAYADJ(IMONTH(I),IDAY(I),IYEAR(I),JDATE)
        JDAY(I)=JDATE
500   CONTINUE
      NYEAR=IYEAR(NTOTAL)-IYEAR(1)+1
      YEAR(1)=IYEAR(1)
      MM=1
      DO 550 I=2,NTOTAL
        IF(IYEAR(I)-YEAR(MM).EQ.1) THEN
          MM=MM+1
          YEAR(MM)=IYEAR(I)
        END IF
550   CONTINUE
C
C     1. TERRESTRIAL IA-2 - DEPTH OF WATER TABLE'
C
      READ(9,181) ITEM1
      WRITE(*,*) ITEM1
181   FORMAT(I2)
      IF(ITEM1.EQ.1) THEN
        OPEN(6,FILE='ITEM1.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,251) EMONTH,EDAY
```

```
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 560 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
560       CONTINUE
        ELSE
          NNY=NYEAR
          DO 570 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
570       CONTINUE
        END IF
        AVG=0
        MM=0
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        DO 580 J=BB,NNY
          DO 110 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            AVG=AVG+FLOW(I)
            MM=MM+1
110       CONTINUE
580     CONTINUE
        AVG=AVG/FLOAT(MM)
        WRITE(6,*) '1. TERRESTRIAL IA-2 - DEPTH OF WATER TABLE'
        WRITE(6,111) BMONTH,BDAY,EMONTH,EDAY,AVG
      ELSE
        READ(9,201)
      END IF
111   FORMAT(/'THE AVERAGE FLOW OF ',I2,'/',I2,' --- ',I2,'/',I2,
     +      ' IS',F8.0,' CFS!'/)
191   FORMAT(I2,1X,I2)
251   FORMAT(I2,1X,I2//)
201   FORMAT(///)
      CLOSE(6)
C
C     2. TERRESTRIAL IA-3 - FLOOD EVENTS SUITABLE FOR PLANT ESTABLISHMENT
C
      READ(9,181) ITEM2
      WRITE(*,*) ITEM2
      IF(ITEM2.EQ.2) THEN
        OPEN(6,FILE='ITEM2.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,211) IDUR
        READ(9,221) SLIMIT
        READ(9,231) RY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 590 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
590       CONTINUE
        ELSE
```

```
          NNY=NYEAR
          DO 600 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
600       CONTINUE
        END IF
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        M2=0
        DO 610 J=BB,NNY
          M2=M2+1
          TEMP=-999
          DO 620 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            IF(FLOW(I).GE.TEMP) THEN
              TEMP=FLOW(I)
              MAXDAY=JDAY(I)
            END IF
620       CONTINUE
          IF(EDATE(J).GE.MAXDAY-7) THEN
            M1=0
            DO 630 I=EDATE(J)-VERYB+1,MAXDAY-VERYB+1+7,-7
              IF((STAGE(I-6)-STAGE(I)).LE.SLIMIT) THEN
                M1=M1+1
                YMAXQ1(M1)=MIN(FLOW(I),FLOW(I-1),FLOW(I-1),
     +                         FLOW(I-3),FLOW(I-3),FLOW(I-3),
     +                         FLOW(I-6))
              ELSE
                GO TO 1025
              END IF
630         CONTINUE
1025        IF(M1.EQ.0) THEN
              YMAXQ(M2)=0
            ELSE
              CALL SORTING(M1,YMAXQ1,IY)
              YMAXQ(M2)=YMAXQ1(1)
            END IF
          ELSE
            YMAXQ(M2)=0
          END IF
          JDY(M2)=IYEAR(MAXDAY-VERYB+1)
610     CONTINUE
        CALL SORTING(M2,YMAXQ,JDY)
        FREQ1=1/RY1
        DO 640 I=1,M2
          FREQS(I)=FLOAT(I)/FLOAT(M2+1)
640     CONTINUE
        DO 650 I=1,M2-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +         (FREQS(I+1)-FREQS(I))
            IF(ABS(YMAXQ(I)-Q1).GT.ABS(YMAXQ(I+1)-Q1)) THEN
              THEYEAR=JDY(I+1)
            ELSE
              THEYEAR=JDY(I)
```

```
            END IF
          END IF
650     CONTINUE
        WRITE(6,*) '2. TERRESTRIAL IA-3 - FLOOD EVENTS SUITABLE',
     +            ' FOR PLANT ESTABLISHMENT'
        WRITE(6,131) RY1,Q1,THEYEAR,RY1,
     +             BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,141) IDUR,SLIMIT,IDUR
        WRITE(6,51) (FREQS(I),YMAXQ(I),I=1,M2)
      ELSE
        READ(9,241)
      END IF
131   FORMAT(/'THE ',F4.1,'-YEAR FLOW IS',F8.0//
     +        'THE YEAR ',I4,' HAS AN EQUIVELENT FLOW OF ',F4.1,
     +        '-YEAR FOR THE SEASON OF ',I2,'/',I2,' --- ',
     +        I2,'/',I2//)
141   FORMAT('SEASONAL',I3,'-DAY FLOW W/ STAGE DECLINE RATE < ',F5.2,
     +       ' FT/(',I3,'-DAY) -- FREQUENCY CURVE'/'AT THE INDEX',
     +       ' LOCATION IS:'//'FREQUENCY  FLOW,CFS'/)
51    FORMAT(2X,F8.3,2X,F8.0)
211   FORMAT(I3)
221   FORMAT(F5.2)
231   FORMAT(F4.1//)
241   FORMAT(//////)
      CLOSE(6)
C
C     3. TERRESTRIAL IA-4 - SCOUR REGIME OF RIPARIAN AND CHANNEL ZONES
C
      READ(9,181) ITEM3
      WRITE(*,*) ITEM3
      IF(ITEM3.EQ.3) THEN
        OPEN(6,FILE='ITEM3.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,261) RY1
        READ(9,231) RY2
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 660 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
660       CONTINUE
        ELSE
          NNY=NYEAR
          DO 670 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
670       CONTINUE
        END IF
        DO 700 I=1,100
          YMAXQ(I)=-999
700     CONTINUE
        DO 690 J=1,NNY
          DO 680 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            IF(FLOW(I).GE.YMAXQ(J)) THEN
              YMAXQ(J)=FLOW(I)
            END IF
```

```
680        CONTINUE
690      CONTINUE
         CALL SORTING(NNY,YMAXQ,JDY)
         FREQ1=1/RY1
         FREQ2=1/RY2
         DO 710 I=1,NNY
           FREQS(I)=FLOAT(I)/FLOAT(NNY+1)
710      CONTINUE
         DO 720 I=1,NNY-1
           IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
             Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
           END IF
           IF(FREQ2.GT.FREQS(I).AND.FREQ2.LE.FREQS(I+1)) THEN
             Q2=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ2)/
     +          (FREQS(I+1)-FREQS(I))
           END IF
720      CONTINUE
         WRITE(6,*) '3. TERRESTRIAL IA-4 - SCOUR REGIME OF',
     +              ' RIPARIAN AND CHANNEL ZONES'
         WRITE(6,41) RY1,Q1,RY2,Q2,BMONTH,BDAY,EMONTH,EDAY
         WRITE(6,91) BMONTH,BDAY,EMONTH,EDAY
         WRITE(6,51) (FREQS(J),YMAXQ(J),J=1,NNY)
       ELSE
         READ(9,271)
       END IF
261    FORMAT(F4.1)
271    FORMAT(/////)
41     FORMAT(/'THE ',F4.1,'-YEAR FLOW IS',F8.0,' CFS',
     +        /'THE ',F4.1,'-YEAR FLOW IS',F8.0,' CFS'//
     +        'BOTH FLOWS ARE BASED ON THE SEASON ',I2,'/',I2,
     +        ' --- ',I2,'/',I2//)
91     FORMAT('THE ',I2,'/',I2,' --- ',I2,'/',I2,' FLOW-',
     +        'FREQUENCY CURVE USED HERE IS:'//
     +        ' FREQUENCY  FLOW, CFS'/)
       CLOSE(6)
C
C      4. TERRESTRIAL IA-5 - INUNDATION OF CHANNEL MARGIN HABITAT
C
       READ(9,181) ITEM4
       IF(ITEM2.NE.2) THEN
         WRITE(*,*) ITEM2
       ELSE
         WRITE(*,*) ITEM4
       END IF
       IF(ITEM4.EQ.4.AND.ITEM2.EQ.2) THEN
         OPEN(6,FILE='ITEM4.OUT',STATUS='UNKNOWN')
         READ(9,191) BMONTH,BDAY
         READ(9,191) EMONTH,EDAY
         READ(9,281) IDUR
         CALL DAYADJ(BMONTH,BDAY,THEYEAR,BDATE(1))
         CALL DAYADJ(EMONTH,EDAY,THEYEAR,EDATE(1))
         M1=0
         DO 730 I=BDATE(1)-VERYB+1,EDATE(1)-VERYB+1
           M1=M1+1
           SEASONQ(M1)=FLOW(I)
730      CONTINUE
```

```
          CALL DURATION(SEASONQ,M1,IDUR,QHIGH)
          WRITE(6,161)
          WRITE(6,171) IDUR,BMONTH,BDAY,EMONTH,EDAY,
     +                 THEYEAR,QHIGH
        ELSE
          READ(9,421)
        END IF
161     FORMAT('4. TERRESTRIAL IA-5 - INUNDATION OF CHANNEL',
     +         ' MARGIN HABITAT'/)
171     FORMAT('THE HIGHEST',I3,'-DAY FLOW OF ',I2,'/',I2,
     +         ' --- ',I2,'/',I2,' IN THE YEAR ',I4,' IS',
     +         F8.0,' CFS')
281     FORMAT(I3//)
421     FORMAT(////)
        CLOSE(6)
C
C       5. TERRESTRIAL IB-1 - RATES OF CHANNEL MIGRATION
C
        READ(9,181) ITEM5
        WRITE(*,*) ITEM5
        IF(ITEM5.EQ.5) THEN
          OPEN(6,FILE='ITEM5.OUT',STATUS='UNKNOWN')
          READ(9,191) BMONTH,BDAY
          READ(9,191) EMONTH,EDAY
          READ(9,261) RY1
          READ(9,231) RY2
          IF(BMONTH.GT.EMONTH) THEN
            NNY=NYEAR-1
            DO 740 I=1,NNY
              CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
              CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
740         CONTINUE
          ELSE
            NNY=NYEAR
            DO 750 I=1,NNY
              CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
              CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
750         CONTINUE
          END IF
          DO 760 I=1,100
            YMAXQ(I)=-999
760       CONTINUE
          DO 770 J=1,NNY
            DO 780 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
              IF(FLOW(I).GE.YMAXQ(J)) THEN
                YMAXQ(J)=FLOW(I)
              END IF
780         CONTINUE
770       CONTINUE
          CALL SORTING(NNY,YMAXQ,JDY)
          FREQ1=1/RY1
          FREQ2=1/RY2
          DO 790 I=1,NNY
            FREQS(I)=FLOAT(I)/FLOAT(NNY+1)
790       CONTINUE
          DO 800 I=1,NNY-1
            IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
```

```
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
          IF(FREQ2.GT.FREQS(I).AND.FREQ2.LE.FREQS(I+1)) THEN
            Q2=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ2)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
800     CONTINUE
        WRITE(6,*) '5. TERRESTRIAL IB-1 - RATES OF CHANNEL MIGRATION'
        WRITE(6,41) RY1,Q1,RY2,Q2,BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,91) BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,51) (FREQS(J),YMAXQ(J),J=1,NNY)
      ELSE
        READ(9,271)
      END IF
      CLOSE(6)
C
C     6. TERRESTRIAL IB-2 - FREQUENCY OF FLOOD SCOUR
C
      READ(9,181) ITEM6
      IF(ITEM2.NE.2) THEN
        WRITE(*,*) ITEM2
      ELSE
        WRITE(*,*) ITEM6
      END IF
      IF(ITEM6.EQ.6.AND.ITEM2.EQ.2) THEN
        OPEN(6,FILE='ITEM6.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,261) RY1
        READ(9,261) RY2
        READ(9,191) BMONTH1,BDAY1
        READ(9,191) EMONTH1,EDAY1
        READ(9,281) IDUR
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 810 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
810       CONTINUE
        ELSE
          NNY=NYEAR
          DO 820 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
820       CONTINUE
        END IF
        DO 830 I=1,100
          YMAXQ(I)=-999
830     CONTINUE
        DO 840 J=1,NNY
          DO 850 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            IF(FLOW(I).GE.YMAXQ(J)) THEN
              YMAXQ(J)=FLOW(I)
            END IF
850       CONTINUE
840     CONTINUE
```

```
        CALL SORTING(NNY,YMAXQ,JDY)
        FREQ1=1/RY1
        FREQ2=1/RY2
        DO 860 I=1,NNY
          FREQS(I)=FLOAT(I)/FLOAT(NNY+1)
860     CONTINUE
        DO 870 I=1,NNY-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
          IF(FREQ2.GT.FREQS(I).AND.FREQ2.LE.FREQS(I+1)) THEN
            Q2=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ2)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
870     CONTINUE
        WRITE(6,*) '6. TERRESTRIAL IB-2 - FREQUENCY OF FLOOD SCOUR'
        WRITE(6,311) RY1,Q1,RY2,Q2,BMONTH,BDAY,EMONTH,EDAY
C
        CALL DAYADJ(BMONTH1,BDAY1,THEYEAR,BDATE(1))
        CALL DAYADJ(EMONTH1,EDAY1,THEYEAR,EDATE(1))
        M1=0
        DO 880 I=BDATE(1)-VERYB+1,EDATE(1)-VERYB+1
          M1=M1+1
          SEASONQ(M1)=FLOW(I)
880     CONTINUE
        CALL DURATION(SEASONQ,M1,IDUR,QHIGH)
        WRITE(6,301) IDUR,THEYEAR,QHIGH
        WRITE(6,91) BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,51) (FREQS(J),YMAXQ(J),J=1,NNY)
      ELSE
        READ(9,291)
      END IF
291   FORMAT(////////)
301   FORMAT('THE HIGHEST',I3,'-DAY FLOW IN THE YEAR ',I4,' IS',
     +       F8.0,' CFS'/)
311   FORMAT(/'THE ',F4.1,'-YEAR FLOW IS',F8.0,' CFS',
     +       /'THE ',F4.1,'-YEAR FLOW IS',F8.0,' CFS'//
     +       'BOTH FLOWS ARE BASED ON THE SEASON ',I2,'/',I2,
     +       ' --- ',I2,'/',I2/)
      CLOSE(6)
C
C     7. TERRESTRIAL IB-4 - RATES OF GERMINATION FLOWS
C
      READ(9,181) ITEM7
      WRITE(*,*) ITEM7
      IF(ITEM7.EQ.7) THEN
        OPEN(6,FILE='ITEM7.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,211) IDUR
        READ(9,221) SLIMIT
        READ(9,231) RY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 890 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
```

```
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
890       CONTINUE
        ELSE
          NNY=NYEAR
          DO 900 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
900       CONTINUE
        END IF
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        M2=0
        DO 910 J=BB,NNY
          M2=M2+1
          TEMP=-999
          DO 920 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            IF(FLOW(I).GE.TEMP) THEN
              TEMP=FLOW(I)
              MAXDAY=JDAY(I)
            END IF
920       CONTINUE
          IF(EDATE(J).GE.MAXDAY-7) THEN
            M1=0
            DO 930 I=EDATE(J)-VERYB+1,MAXDAY-VERYB+1+IDUR,-1*IDUR
              IF((STAGE(I-6)-STAGE(I)).LE.SLIMIT) THEN
                M1=M1+1
                YMAXQ1(M1)=MIN(FLOW(I),FLOW(I-1),FLOW(I-1),
     +                         FLOW(I-3),FLOW(I-3),FLOW(I-3),
     +                         FLOW(I-6))
              ELSE
                GO TO 1035
              END IF
930         CONTINUE
1035        IF(M1.EQ.0) THEN
              YMAXQ(M2)=0
            ELSE
              CALL SORTING(M1,YMAXQ1,IY)
              YMAXQ(M2)=YMAXQ1(1)
            END IF
          ELSE
            YMAXQ(M2)=0
          END IF
          JDY(M2)=IYEAR(MAXDAY-VERYB+1)
910     CONTINUE
        CALL SORTING(M2,YMAXQ,JDY)
        FREQ1=1/RY1
        DO 940 I=1,M2
          FREQS(I)=FLOAT(I)/FLOAT(M2+1)
940     CONTINUE
        DO 950 I=1,M2-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +         (FREQS(I+1)-FREQS(I))
            IF(ABS(YMAXQ(I)-Q1).GT.ABS(YMAXQ(I+1)-Q1)) THEN
```

```
              THEYEAR=JDY(I+1)
            ELSE
              THEYEAR=JDY(I)
            END IF
          END IF
950     CONTINUE
        WRITE(6,*) '7. TERRESTRIAL IB-4 - RATES OF GERMINATION FLOWS'
        WRITE(6,131) RY1,Q1,THEYEAR,RY1,
     +             BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,141) IDUR,SLIMIT,IDUR
        WRITE(6,51) (FREQS(I),YMAXQ(I),I=1,M2)
      ELSE
        READ(9,321)
      END IF
321   FORMAT(/////)
      CLOSE(6)
C
C     8. AQUATIC IIB-1 - SPAWNING HABITAT ABUNDANCE(EXCEPT OVERLAY
C        WITH VEGETION MAPPING)
C
      READ(9,181) ITEM8
      WRITE(*,*) ITEM8
      IF(ITEM8.EQ.8) THEN
        OPEN(6,FILE='ITEM8.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,211) IDUR
        READ(9,231) RY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 960 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
960       CONTINUE
        ELSE
          NNY=NYEAR
          DO 970 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
970       CONTINUE
        END IF

        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        M2=0
        DO 990 J=BB,NNY
          M1=0
          DO 980 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            M1=M1+1
            SEASONQ(M1)=FLOW(I)
980       CONTINUE
          CALL DURATION(SEASONQ,M1,IDUR,QHIGH)
          M2=M2+1
          YMAXQ(M2)=QHIGH
```

```
990     CONTINUE
        CALL SORTING(M2,YMAXQ,JDY)
        FREQ1=1/RY1
        DO 1000 I=1,M2
          FREQS(I)=FLOAT(I)/FLOAT(M2+1)
1000    CONTINUE
        DO 1010 I=1,M2-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
1010    CONTINUE
        WRITE(6,351)
        WRITE(6,341) INT(RY1),IDUR,Q1,BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,51) (FREQS(I),YMAXQ(I),I=1,M2)
      ELSE
        READ(9,331)
      END IF
341   FORMAT('THE ',I2,'-YEAR SEASONAL ',I3,'-DAY FLOW IS',F8.0,
     +       ' CFS'//'(THE SEASON USED HERE IS: ',
     +       I2,'/',I2,' --- ',I2,'/',I2,')'//'THE SEASONAL ',
     +       'FLOW-FREQUENCY CURVE USED HERE IS:'/
     +       'EXCEEDANCE   FLOW,CFS')
331   FORMAT(/////)
351   FORMAT('8. AQUATIC IIB-1 - SPAWNING HABITAT ABUNDANCE',
     +       ' (EXCEPT OVERLAY WITH VEGETION MAPPING)'/)
      CLOSE(6)
C
C     9. AQUATIC IIC-1 - REARING HABITAT ABUNDANCE(EXCEPT OVERLAY
C        WITH VEGETION MAPPING)
C
      READ(9,181) ITEM9
      WRITE(*,*) ITEM9
      IF(ITEM9.EQ.9) THEN
        OPEN(6,FILE='ITEM9.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,211) IDUR
        READ(9,231) RY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 1020 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
1020      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1030 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
1030      CONTINUE
        END IF

        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
```

```
        END IF
        M2=0
        DO 1040 J=BB,NNY
          M1=0
          DO 1050 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            M1=M1+1
            SEASONQ(M1)=FLOW(I)
1050      CONTINUE
          CALL DURATION(SEASONQ,M1,IDUR,QHIGH)
          M2=M2+1
          YMAXQ(M2)=QHIGH
1040    CONTINUE
        CALL SORTING(M2,YMAXQ,JDY)
        FREQ1=1/RY1
        DO 1060 I=1,M2
          FREQS(I)=FLOAT(I)/FLOAT(M2+1)
1060    CONTINUE
        DO 1070 I=1,M2-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
1070    CONTINUE
        WRITE(6,361)
        WRITE(6,341) INT(RY1),IDUR,Q1,BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,51) (FREQS(I),YMAXQ(I),I=1,M2)
      ELSE
        READ(9,331)
      END IF
361   FORMAT('9. AQUATIC IIC-1 - REARING HABITAT ABUNDANCE',
     +       ' (EXCEPT OVERLAY WITH VEGETION MAPPING)'/)
      CLOSE(6)
C
C     10. AQUATIC IIC-3. FLOODPLAIN-CHANNEL CONNECTIVITY
C
      READ(9,181) ITEM10
      WRITE(*,*) ITEM10
      IF(ITEM10.EQ.10) THEN
        OPEN(6,FILE='ITEM10.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,191) BMONTH1,BDAY1
        READ(9,191) EMONTH1,EDAY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 1080 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
1080      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1090 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
1090      CONTINUE
        END IF
        AVG=0
```

```
        MM=0
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        DO 1110 J=BB,NNY
          DO 1230 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            AVG=AVG+FLOW(I)
            MM=MM+1
1230      CONTINUE
1110    CONTINUE
        AVG=AVG/FLOAT(MM)
        WRITE(6,*) '10. AQUATIC IIC-3. FLOODPLAIN-CHANNEL CONNECTIVITY'
        WRITE(6,371) BMONTH,BDAY,EMONTH,EDAY,AVG
C
        IF(BMONTH1.GT.EMONTH1) THEN
          NNY=NYEAR-1
          DO 1120 I=1,NNY
            CALL DAYADJ(BMONTH1,BDAY1,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH1,EDAY1,YEAR(I+1),EDATE(I))
1120      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1130 I=1,NNY
            CALL DAYADJ(BMONTH1,BDAY1,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH1,EDAY1,YEAR(I),EDATE(I))
1130      CONTINUE
        END IF
        AVG1=0
        MM=0
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        DO 1140 J=BB,NNY
          DO 1150 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            AVG1=AVG1+FLOW(I)
            MM=MM+1
1150      CONTINUE
1140    CONTINUE
        AVG1=AVG1/FLOAT(MM)
        WRITE(6,371) BMONTH1,BDAY1,EMONTH1,EDAY1,AVG1
        IF(AVG.GT.AVG1) THEN
          WRITE(6,381) AVG
        ELSE
          WRITE(6,381) AVG1
        END IF
C
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,231) RY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 1160 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
```

```
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
1160      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1170 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
1170      CONTINUE
        END IF
        DO 1180 I=1,100
          YMAXQ(I)=-999
1180    CONTINUE
        DO 1190 J=1,NNY
          DO 1200 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            IF(FLOW(I).GE.YMAXQ(J)) THEN
              YMAXQ(J)=FLOW(I)
            END IF
1200      CONTINUE
1190    CONTINUE
        CALL SORTING(NNY,YMAXQ,JDY)
        FREQ1=1/RY1
        DO 1210 I=1,NNY
          FREQS(I)=FLOAT(I)/FLOAT(NNY+1)
1210    CONTINUE
        DO 1220 I=1,NNY-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +         (FREQS(I+1)-FREQS(I))
          END IF
1220    CONTINUE
        WRITE(6,391) RY1,Q1,BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,91) BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,51) (FREQS(J),YMAXQ(J),J=1,NNY)
      ELSE
        READ(9,401)
      END IF
371   FORMAT(/'THE AVERAGE FLOW OF ',I2,'/',I2,' --- ',I2,'/',I2,
     +      ' IS',F8.0,' CFS!')
381   FORMAT(/'THE LARGER FLOW BETWEEN THESE TWO SEASON IS ',
     +       F8.0,' CFS'/)
391   FORMAT(/'THE ',F4.1,'-YEAR FLOW IS',F8.0,' CFS'//
     +       'THE FLOW IS ESTIMATED BASED ON THE SEASON ',I2,
     +       '/',I2,' --- ',I2,'/',I2/)
401   FORMAT(////////)
      CLOSE(6)
C
C     11. AQUATIC IIE-1 - RATE OF RECRUITMENT OF INSTREAM WOODY MATERIAL
C
      READ(9,181) ITEM11
      WRITE(*,*) ITEM11
      IF(ITEM11.EQ.11) THEN
        OPEN(6,FILE='ITEM11.OUT',STATUS='UNKNOWN')
        READ(9,191) BMONTH1,BDAY1
        READ(9,191) EMONTH1,EDAY1
        READ(9,261) RY1
        READ(9,261) RY2
        IF(BMONTH1.GT.EMONTH1) THEN
```

```
          NNY=NYEAR-1
          DO 1240 I=1,NNY
            CALL DAYADJ(BMONTH1,BDAY1,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH1,EDAY1,YEAR(I+1),EDATE(I))
1240      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1250 I=1,NNY
            CALL DAYADJ(BMONTH1,BDAY1,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH1,EDAY1,YEAR(I),EDATE(I))
1250      CONTINUE
        END IF
        DO 1260 I=1,100
          YMAXQ(I)=-999
1260    CONTINUE
        DO 1280 J=1,NNY
          DO 1270 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            IF(FLOW(I).GE.YMAXQ(J)) THEN
              YMAXQ(J)=FLOW(I)
            END IF
1270      CONTINUE
1280    CONTINUE
        CALL SORTING(NNY,YMAXQ,JDY)
        FREQ1=1/RY1
        FREQ2=1/RY2
        DO 1290 I=1,NNY
          FREQS(I)=FLOAT(I)/FLOAT(NNY+1)
1290    CONTINUE
        DO 1300 I=1,NNY-1
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
          IF(FREQ2.GT.FREQS(I).AND.FREQ2.LE.FREQS(I+1)) THEN
            Q2=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ2)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
1300    CONTINUE
        WRITE(6,*) '11. AQUATIC IIE-1 - RATE OF RECRUITMENT OF',
     +             ' INSTREAM WOODY MATERIAL'
        WRITE(6,41) RY1,Q1,RY2,Q2,BMONTH1,BDAY1,EMONTH1,EDAY1
        WRITE(6,91) BMONTH1,BDAY1,EMONTH1,EDAY1
        WRITE(6,51) (FREQS(J),YMAXQ(J),J=1,NNY)
C
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 1310 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
1310      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1320 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
```

```
1320      CONTINUE
        END IF
        AVG=0
        MM=0
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        DO 1330 J=BB,NNY
          DO 1340 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            AVG=AVG+FLOW(I)
            MM=MM+1
1340      CONTINUE
1330    CONTINUE
        AVG=AVG/FLOAT(MM)
        WRITE(6,111) BMONTH,BDAY,EMONTH,EDAY,AVG
C
        READ(9,191) BMONTH,BDAY
        READ(9,191) EMONTH,EDAY
        READ(9,211) IDUR
        READ(9,411) RY1
        IF(BMONTH.GT.EMONTH) THEN
          NNY=NYEAR-1
          DO 1350 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I+1),EDATE(I))
1350      CONTINUE
        ELSE
          NNY=NYEAR
          DO 1360 I=1,NNY
            CALL DAYADJ(BMONTH,BDAY,YEAR(I),BDATE(I))
            CALL DAYADJ(EMONTH,EDAY,YEAR(I),EDATE(I))
1360      CONTINUE
        END IF
        IF(BDATE(1)-VERYB.LT.0) THEN
          BB=2
        ELSE
          BB=1
        END IF
        M2=0
        DO 1380 J=BB,NNY
          M1=0
          DO 1370 I=BDATE(J)-VERYB+1,EDATE(J)-VERYB+1
            M1=M1+1
            SEASONQ(M1)=FLOW(I)
1370      CONTINUE
          CALL DURATION(SEASONQ,M1,IDUR,QHIGH)
          M2=M2+1
          YMAXQ(M2)=QHIGH
1380    CONTINUE
        CALL SORTING(M2,YMAXQ,JDY)
        FREQ1=1/RY1
        DO 1390 I=1,M2
          FREQS(I)=FLOAT(I)/FLOAT(M2+1)
1390    CONTINUE
        DO 1400 I=1,M2-1
```

```
          IF(FREQ1.GT.FREQS(I).AND.FREQ1.LE.FREQS(I+1)) THEN
            Q1=YMAXQ(I+1)+(YMAXQ(I)-YMAXQ(I+1))*(FREQS(I+1)-FREQ1)/
     +          (FREQS(I+1)-FREQS(I))
          END IF
1400    CONTINUE
        WRITE(6,341) INT(RY1),IDUR,Q1,BMONTH,BDAY,EMONTH,EDAY
        WRITE(6,51) (FREQS(I),YMAXQ(I),I=1,M2)
      END IF
      CLOSE(6)
411   FORMAT(F4.1)
C
5000  STOP
      END


      SUBROUTINE SORTING(N,YMAXQ,IY)
C     THIS SUBROUTINE IS TO SORT DATA IN A DESCENDING ORDER
      INTEGER N,IY(N),ITEMP
      REAL YMAXQ(N),TEMP
      DO 10 I=1,N-1
        DO 20 J=1,N-1
          IF(YMAXQ(J+1).GT.YMAXQ(J)) THEN
            TEMP=YMAXQ(J)
            YMAXQ(J)=YMAXQ(J+1)
            YMAXQ(J+1)=TEMP
            ITEMP=IY(J)
            IY(J)=IY(J+1)
            IY(J+1)=ITEMP
          END IF
20      CONTINUE
10    CONTINUE
      RETURN
      END


      SUBROUTINE DURATION(Q,N,IDUR,QMAX)
C     THIS SUBROUTINE IS TO GET HIGHEST FLOW/STAGE FOR A IDUR-DAY DURATION
      INTEGER N,IDUR
      REAL Q(N),QMIN(366),QMAX
C
      DO 10 I=1,N-IDUR+1
        QMIN(I)=999999
        DO 20 J=I,I+IDUR-1
          IF(Q(J).LT.QMIN(I)) QMIN(I)=Q(J)
20      CONTINUE
10    CONTINUE
      QMAX=-9999
      DO 30 I=1,N-IDUR+1
        IF(QMIN(I).GT.QMAX) QMAX=QMIN(I)
30    CONTINUE
      RETURN
      END


      SUBROUTINE DAYADJ(MONTH,DAY,YEAR,JDATE)
C     THIS SUBROUTINE IS TO CONVERT CALENDER DATE TO SERIES DATE
      INTEGER MONTH,DAY,YEAR,JDATE,NUM(12),NUM1(12),ITEMP,IYEAR
```

```
      DATA NUM/31,28,31,30,31,30,31,31,30,31,30,31/
      DATA NUM1/31,29,31,30,31,30,31,31,30,31,30,31/
      IYEAR=YEAR-1900
      IF(MOD(IYEAR,4) .NE. 0) THEN
        JDATE=IYEAR*365+(IYEAR-MOD(IYEAR,4))/4+1
      ELSE
        JDATE=IYEAR*365+(IYEAR-MOD(IYEAR,4))/4
      END IF
      ITEMP=0
      IF(MONTH .NE.1 ) THEN
        IF(MOD(YEAR,4) .NE. 0) THEN
          DO 10 I=1,MONTH-1
            ITEMP=ITEMP+NUM(I)
10        CONTINUE
        ELSE
          DO 20 I=1,MONTH-1
            ITEMP=ITEMP+NUM1(I)
20        CONTINUE
        END IF
      END IF
      JDATE=JDATE+ITEMP+DAY
      END
```

ATTACHMENT G2

INPUT COMMAND FILE TO THE EFM STATISTICAL ANALYSIS FORTRAN SOFTWARE PACKAGE

```
Enter the name of the data file containing the daily flow in cfs and stage
in ft
VERNALIS.PRN    format(A12)

1. Terrestrial IA-2 - depth of water table
01          format(I2),   if 0, not selected
08/01       format(I2,'/',I2),    beginning of the season
08/31       format(I2,'/',I2),    end of the season

2. Terrestrial IA-3 - flood events suitable for plant establishment
02          format(I2),   if 0, not selected
04/01       format(I2,'/',I2),    beginning of the season
07/15       format(I2,'/',I2),    end of the season
007         format(I3),   duration in days
 0.88       format(F5.2)   rate of recession in ft/duration in days
10.0        format(f4.1),   return period

3. Terrestrial IA-4 - scour regime of riparian and channel zones
03          format(I2),   if 0, not selected
10/01       format(I2,'/',I2),    beginning of the season
09/30       format(I2,'/',I2),    end of the season
 5.0        format(F4.1),   return period 1
10.0        format(F4.1),   return period 2

4. Terrestrial IA-5 - inundation of channel margin habitat
04          format(I2),   if 0, not selected.  IA-3 has to be selected in
order to select this item
07/15       format(I2,'/',I2),    beginning of the season
08/15       format(I2,'/',I2),    end of the season
021         format(I3),   duration in days

5. Terrestrial IB-1 - rates of channel migration
05          format(I2),   if 0, not selected
10/01       format(I2,'/',I2),    beginning of the season
09/30       format(I2,'/',I2),    end of the season
 1.5        format(F4.1),   return period 1
 5.0        format(F4.1),   return period 2

6. Terrestrial IB-2 - frequency of flood scour
06          format(I2),   if 0, not selected.  IA-3 has to be selected in
order to select this item
10/01       format(I2,'/',I2),    beginning of the season
09/30       format(I2,'/',I2),    end of the season
05.0        format(F4.1),   return period 1
10.0        format(F4.1),   return period 2
07/15       format(I2,'/',I2),    beginning of the season
08/15       format(I2,'/',I2),    end of the season
021         format(I3),   duration in days
```

```
7. Terrestrial IB-4 - rates of germination flows
07          format(I2),   if 0, not selected
04/01       format(I2,'/',I2),    beginning of the season
07/15       format(I2,'/',I2),    end of the season
007         format(I3),   duration in days
 0.88       format(F5.2) rate of recession in ft/duration in days
10.0        format(f4.1),   return period

8. Aquatic IIB-1 - spawning habitat abundance (except overlay with
vegetation mapping)
08          format(I2),   if 0, not selected
02/01       format(I2,'/',I2),    beginning of the season
05/31       format(I2,'/',I2),    end of the season
021         format(I3),   duration in days
 4.0        format(F4.1),   return period

9. Aquatic IIC-1 - rearing habitat abundance (except overlay with
vegetation mapping)
09          format(I2),   if 0, not selected
12/01       format(I2,'/',I2),    beginning of the season
05/31       format(I2,'/',I2),    end of the season
007         format(I3),   duration in days
 4.0        format(F4.1),   return period

10. Aquatic IIC-3 - floodplain-channel connectivity
10          format(I2),   if 0, not selected
04/01       format(I2,'/',I2),    beginning of the season 1
04/30       format(I2,'/',I2),    end of the season 1
05/01       format(I2,'/',I2),    beginning of the season 2
05/31       format(I2,'/',I2),    end of the season 2
10/01       format(I2,'/',I2),    beginning of the season 3 (annual)
09/30       format(I2,'/',I2),    end of the season 3 (annual)
 3.0        format(F4.1),   return period

11. Aquatic IIE-1 - rate of recruitment of instream woody material
11          format(I2),   if 0, not selected.
10/01       format(I2,'/',I2),    beginning of the season
09/30       format(I2,'/',I2),    end of the season
 1.5        format(F4.1),   return period 1
 5.0        format(F4.1),   return period 2
08/01       format(I2,'/',I2),    beginning of the season
08/31       format(I2,'/',I2),    end of the season
07/15       format(I2,'/',I2),    beginning of the season
09/30       format(I2,'/',I2),    end of the season
021         format(I3),   duration in days
10.0        format(f4.1),   return period
```

ATTACHMENT G3

SAMPLE INPUT DATA FILE TO THE EFM STATISTICAL ANALYSIS FORTRAN SOFTWARE PACKAGE

The following input data file for the EFM statistical analysis software package was developed for the San Joaquin River at Vernalis pilot study. This data represents daily flow records from the USGS gage 11303530, San Joaquin River at Vernalis for the period of record, 10/1/1929 through 9/29/2000 (the entire data record is not shown below for space considerations).

```
10/01/1929   1390.0    2.48
10/02/1929   1490.0    2.63
10/03/1929   1540.0    2.71
10/04/1929   1490.0    2.63
10/05/1929   1540.0    2.71
10/06/1929   1540.0    2.71
10/07/1929   1540.0    2.71
10/08/1929   1490.0    2.63
10/09/1929   1440.0    2.56
10/10/1929   1440.0    2.56
10/11/1929   1340.0    2.40
10/12/1929   1290.0    2.32
10/13/1929   1290.0    2.32
10/14/1929   1340.0    2.40
10/15/1929   1440.0    2.56
10/16/1929   1490.0    2.63
10/17/1929   1540.0    2.71
10/18/1929   1540.0    2.71
10/19/1929   1490.0    2.63
10/20/1929   1440.0    2.56
.
.
.
.
09/13/2000   2250.0    3.76
09/14/2000   2240.0    3.74
09/15/2000   2410.0    3.99
09/16/2000   2940.0    4.73
09/17/2000   2450.0    4.04
09/18/2000   2250.0    3.76
09/19/2000   2130.0    3.58
09/20/2000   2290.0    3.82
09/21/2000   2420.0    4.00
09/22/2000   2350.0    3.90
09/23/2000   2460.0    4.06
09/24/2000   2530.0    4.16
09/25/2000   2520.0    4.14
09/26/2000   2370.0    3.93
09/27/2000   2200.0    3.69
09/28/2000   2050.0    3.47
09/29/2000   1970.0    3.35
09/30/2000   1960.0    3.34
```

ATTACHMENT G4

SAMPLE OUTPUT FILES FROM THE EFM STATISTICAL ANALYSIS FORTRAN SOFTWARE PACKAGE

Output File Name: Item1.out

```
1. TERRESTRIAL IA-2 - DEPTH OF WATER TABLE

THE AVERAGE FLOW OF  8/ 1 ---  8/31 IS   1458. CFS!
```

Output File Name: Item2.out

```
2. TERRESTRIAL IA-3 - FLOOD EVENTS SUITABLE FOR PLANT ESTABLISHMENT

THE 10.0-YEAR FLOW IS   2924.

THE YEAR 1987 HAS AN EQUIVELENT FLOW OF 10.0-YEAR FOR THE SEASON OF  4/ 1
---  7/15

SEASONAL  7-DAY FLOW W/ STAGE DECLINE RATE <  0.88 FT/(  7-DAY) --
FREQUENCY CURVE
AT THE INDEX LOCATION IS:

FREQUENCY  FLOW,CFS

     0.014    29700.
     0.028    15300.
     0.042    11200.
     0.056     3550.
     0.069     3540.
     0.083     3440.
     0.097     2940.
     0.111     2860.
     0.125     2650.
     0.139     2640.
     0.153     2620.
     0.167     2430.
     0.181     2020.
     0.194     2010.
     0.208     1910.
     0.222     1910.
     0.236     1910.
     0.250     1900.
     0.264     1840.
     0.278     1820.
     0.292     1780.
     0.306     1540.
     0.319     1480.
     0.333     1470.
     0.347     1450.
```

```
     0.361     1420.
     0.375     1290.
     0.389     1190.
     0.403     1150.
     0.417     1140.
     0.431     1140.
     0.444     1120.
     0.458     1100.
     0.472     1100.
     0.486     1070.
     0.500      970.
     0.514      955.
     0.528      940.
     0.542      935.
     0.556      915.
     0.569      910.
     0.583      895.
     0.597      840.
     0.611      834.
     0.625      776.
     0.639      735.
     0.653      648.
     0.667      595.
     0.681      590.
     0.694      424.
     0.708      406.
     0.722      298.
     0.736        0.
     0.750        0.
     0.764        0.
     0.778        0.
     0.792        0.
     0.806        0.
     0.819        0.
     0.833        0.
     0.847        0.
     0.861        0.
     0.875        0.
     0.889        0.
     0.903        0.
     0.917        0.
     0.931        0.
     0.944        0.
     0.958        0.
     0.972        0.
     0.986        0.
```

Output File Name: Item3.out

```
3. TERRESTRIAL IA-4 - SCOUR REGIME OF RIPARIAN AND CHANNEL ZONES

THE  5.0-YEAR FLOW IS  33340. CFS
THE 10.0-YEAR FLOW IS  40220. CFS
```

```
BOTH FLOWS ARE BASED ON THE SEASON 10/ 1 ---  9/30


THE 10/ 1 ---  9/30 FLOW-FREQUENCY CURVE USED HERE IS:

 FREQUENCY  FLOW, CFS

     0.014    70000.
     0.028    54300.
     0.042    50000.
     0.056    47600.
     0.069    47400.
     0.083    44700.
     0.097    40900.
     0.111    37500.
     0.125    36600.
     0.139    36600.
     0.153    35000.
     0.167    34100.
     0.181    33700.
     0.194    33700.
     0.208    32800.
     0.222    29600.
     0.236    28600.
     0.250    27100.
     0.264    26200.
     0.278    26000.
     0.292    25900.
     0.306    25900.
     0.319    24000.
     0.333    23600.
     0.347    22700.
     0.361    20300.
     0.375    18000.
     0.389    17600.
     0.403    16700.
     0.417    16500.
     0.431    16000.
     0.444    14500.
     0.458    13700.
     0.472    13100.
     0.486    12900.
     0.500    12500.
     0.514    11600.
     0.528     9920.
     0.542     9880.
     0.556     9700.
     0.569     9690.
     0.583     9590.
     0.597     9260.
     0.611     8820.
     0.625     8240.
     0.639     7210.
     0.653     6630.
     0.667     6000.
     0.681     5790.
     0.694     5710.
```

```
     0.708     5700.
     0.722     5560.
     0.736     5550.
     0.750     5250.
     0.764     5110.
     0.778     5080.
     0.792     4850.
     0.806     4330.
     0.819     4320.
     0.833     4200.
     0.847     4120.
     0.861     3980.
     0.875     3980.
     0.889     3860.
     0.903     3100.
     0.917     2720.
     0.931     2580.
     0.944     2140.
     0.958     1970.
     0.972     1940.
     0.986     1590.
```

Output File Name: Item4.out

```
4. TERRESTRIAL IA-5 - INUNDATION OF CHANNEL MARGIN HABITAT

THE HIGHEST 21-DAY FLOW OF  7/15 ---  8/15 IN THE YEAR 1987 IS   1420. CFS
```

Output File Name: Item5.out

```
5. TERRESTRIAL IB-1 - RATES OF CHANNEL MIGRATION

THE  1.5-YEAR FLOW IS   6000. CFS
THE  5.0-YEAR FLOW IS  33340. CFS

BOTH FLOWS ARE BASED ON THE SEASON 10/ 1 ---  9/30


THE 10/ 1 ---  9/30 FLOW-FREQUENCY CURVE USED HERE IS:

 FREQUENCY  FLOW, CFS

     0.014    70000.
     0.028    54300.
     0.042    50000.
     0.056    47600.
     0.069    47400.
     0.083    44700.
     0.097    40900.
     0.111    37500.
     0.125    36600.
     0.139    36600.
     0.153    35000.
```

```
      0.167    34100.
      0.181    33700.
      0.194    33700.
      0.208    32800.
      0.222    29600.
      0.236    28600.
      0.250    27100.
      0.264    26200.
      0.278    26000.
      0.292    25900.
      0.306    25900.
      0.319    24000.
      0.333    23600.
      0.347    22700.
      0.361    20300.
      0.375    18000.
      0.389    17600.
      0.403    16700.
      0.417    16500.
      0.431    16000.
      0.444    14500.
      0.458    13700.
      0.472    13100.
      0.486    12900.
      0.500    12500.
      0.514    11600.
      0.528     9920.
      0.542     9880.
      0.556     9700.
      0.569     9690.
      0.583     9590.
      0.597     9260.
      0.611     8820.
      0.625     8240.
      0.639     7210.
      0.653     6630.
      0.667     6000.
      0.681     5790.
      0.694     5710.
      0.708     5700.
      0.722     5560.
      0.736     5550.
      0.750     5250.
      0.764     5110.
      0.778     5080.
      0.792     4850.
      0.806     4330.
      0.819     4320.
      0.833     4200.
      0.847     4120.
      0.861     3980.
      0.875     3980.
      0.889     3860.
      0.903     3100.
      0.917     2720.
      0.931     2580.
      0.944     2140.
```

```
     0.958     1970.
     0.972     1940.
     0.986     1590.
```

Output File Name: Item6.out

```
6. TERRESTRIAL IB-2 - FREQUENCY OF FLOOD SCOUR

THE  5.0-YEAR FLOW IS  33340. CFS
THE 10.0-YEAR FLOW IS  40220. CFS

BOTH FLOWS ARE BASED ON THE SEASON 10/ 1 ---  9/30

THE HIGHEST 21-DAY FLOW IN THE YEAR 1987 IS   1420. CFS

THE 10/ 1 ---  9/30 FLOW-FREQUENCY CURVE USED HERE IS:

 FREQUENCY  FLOW, CFS

     0.014    70000.
     0.028    54300.
     0.042    50000.
     0.056    47600.
     0.069    47400.
     0.083    44700.
     0.097    40900.
     0.111    37500.
     0.125    36600.
     0.139    36600.
     0.153    35000.
     0.167    34100.
     0.181    33700.
     0.194    33700.
     0.208    32800.
     0.222    29600.
     0.236    28600.
     0.250    27100.
     0.264    26200.
     0.278    26000.
     0.292    25900.
     0.306    25900.
     0.319    24000.
     0.333    23600.
     0.347    22700.
     0.361    20300.
     0.375    18000.
     0.389    17600.
     0.403    16700.
     0.417    16500.
     0.431    16000.
     0.444    14500.
     0.458    13700.
     0.472    13100.
     0.486    12900.
     0.500    12500.
```

0.514	11600.
0.528	9920.
0.542	9880.
0.556	9700.
0.569	9690.
0.583	9590.
0.597	9260.
0.611	8820.
0.625	8240.
0.639	7210.
0.653	6630.
0.667	6000.
0.681	5790.
0.694	5710.
0.708	5700.
0.722	5560.
0.736	5550.
0.750	5250.
0.764	5110.
0.778	5080.
0.792	4850.
0.806	4330.
0.819	4320.
0.833	4200.
0.847	4120.
0.861	3980.
0.875	3980.
0.889	3860.
0.903	3100.
0.917	2720.
0.931	2580.
0.944	2140.
0.958	1970.
0.972	1940.
0.986	1590.

Output File Name: Item7.out

7. TERRESTRIAL IB-4 - RATES OF GERMINATION FLOWS

THE 10.0-YEAR FLOW IS 2924.

THE YEAR 1987 HAS AN EQUIVELENT FLOW OF 10.0-YEAR FOR THE SEASON OF 4/ 1 --- 7/15

SEASONAL 7-DAY FLOW W/ STAGE DECLINE RATE < 0.88 FT/(7-DAY) -- FREQUENCY CURVE
AT THE INDEX LOCATION IS:

FREQUENCY	FLOW,CFS
0.014	29700.
0.028	15300.
0.042	11200.

0.056	3550.
0.069	3540.
0.083	3440.
0.097	2940.
0.111	2860.
0.125	2650.
0.139	2640.
0.153	2620.
0.167	2430.
0.181	2020.
0.194	2010.
0.208	1910.
0.222	1910.
0.236	1910.
0.250	1900.
0.264	1840.
0.278	1820.
0.292	1780.
0.306	1540.
0.319	1480.
0.333	1470.
0.347	1450.
0.361	1420.
0.375	1290.
0.389	1190.
0.403	1150.
0.417	1140.
0.431	1140.
0.444	1120.
0.458	1100.
0.472	1100.
0.486	1070.
0.500	970.
0.514	955.
0.528	940.
0.542	935.
0.556	915.
0.569	910.
0.583	895.
0.597	840.
0.611	834.
0.625	776.
0.639	735.
0.653	648.
0.667	595.
0.681	590.
0.694	424.
0.708	406.
0.722	298.
0.736	0.
0.750	0.
0.764	0.
0.778	0.
0.792	0.
0.806	0.
0.819	0.
0.833	0.

```
     0.847        0.
     0.861        0.
     0.875        0.
     0.889        0.
     0.903        0.
     0.917        0.
     0.931        0.
     0.944        0.
     0.958        0.
     0.972        0.
     0.986        0.
```

Output File Name: Item8.out

```
8. AQUATIC IIB-1 - SPAWNING HABITAT ABUNDANCE (EXCEPT OVERLAY WITH
VEGETION MAPPING)

THE  4-YEAR SEASONAL  21-DAY FLOW IS  14800. CFS

(THE SEASON USED HERE IS:  2/ 1 ---  5/31)

THE SEASONAL FLOW-FREQUENCY CURVE USED HERE IS:
EXCEEDANCE   FLOW,CFS
     0.014    37900.
     0.028    32800.
     0.042    30800.
     0.056    30700.
     0.069    30100.
     0.083    25400.
     0.097    24800.
     0.111    23800.
     0.125    23700.
     0.139    22900.
     0.153    22600.
     0.167    21100.
     0.181    20900.
     0.194    19900.
     0.208    18500.
     0.222    15200.
     0.236    14900.
     0.250    14800.
     0.264    14700.
     0.278    14400.
     0.292    13400.
     0.306    13300.
     0.319    13200.
     0.333    11600.
     0.347    11600.
     0.361    10700.
     0.375     9850.
     0.389     9820.
     0.403     9260.
     0.417     8340.
     0.431     7810.
     0.444     7710.
```

```
     0.458     7590.
     0.472     6780.
     0.486     6000.
     0.500     5730.
     0.514     5490.
     0.528     5000.
     0.542     4710.
     0.556     4420.
     0.569     4010.
     0.583     3590.
     0.597     3560.
     0.611     3410.
     0.625     3320.
     0.639     3230.
     0.653     3170.
     0.667     2930.
     0.681     2910.
     0.694     2840.
     0.708     2600.
     0.722     2510.
     0.736     2460.
     0.750     2390.
     0.764     2290.
     0.778     2260.
     0.792     2200.
     0.806     2180.
     0.819     2140.
     0.833     2080.
     0.847     2080.
     0.861     1950.
     0.875     1920.
     0.889     1650.
     0.903     1520.
     0.917     1480.
     0.931     1330.
     0.944     1280.
     0.958     1200.
     0.972      945.
     0.986      525.
```

Output File Name: Item9.out

```
9. AQUATIC IIC-1 - REARING HABITAT ABUNDANCE (EXCEPT OVERLAY WITH VEGETION
MAPPING)

THE  4-YEAR SEASONAL   7-DAY FLOW IS  24400. CFS

(THE SEASON USED HERE IS: 12/ 1 ---  5/31)

THE SEASONAL FLOW-FREQUENCY CURVE USED HERE IS:
EXCEEDANCE   FLOW,CFS
     0.014    41200.
     0.028    39300.
     0.042    37600.
     0.056    37500.
```

```
0.069   35200.
0.083   35200.
0.097   33000.
0.111   32800.
0.125   32000.
0.139   31900.
0.153   29900.
0.167   29300.
0.181   27900.
0.194   27800.
0.208   27700.
0.222   26200.
0.236   25400.
0.250   24400.
0.264   23700.
0.278   23100.
0.292   21000.
0.306   20100.
0.319   19500.
0.333   18900.
0.347   18900.
0.361   18200.
0.375   16800.
0.389   15900.
0.403   15800.
0.417   13800.
0.431   12900.
0.444   11900.
0.458   11100.
0.472   10900.
0.486   10600.
0.500    8830.
0.514    8060.
0.528    7950.
0.542    7110.
0.556    6500.
0.569    6330.
0.583    6330.
0.597    6160.
0.611    6050.
0.625    4890.
0.639    4760.
0.653    4690.
0.667    4600.
0.681    4390.
0.694    4140.
0.708    4130.
0.722    4050.
0.736    3970.
0.750    3640.
0.764    3550.
0.778    3500.
0.792    3410.
0.806    3400.
0.819    3390.
0.833    3370.
0.847    2980.
```

```
     0.861     2700.
     0.875     2420.
     0.889     2390.
     0.903     2340.
     0.917     2330.
     0.931     2020.
     0.944     2000.
     0.958     1910.
     0.972     1470.
     0.986     1130.
```

Output File Name: Item10.out

```
10. AQUATIC IIC-3. FLOODPLAIN-CHANNEL CONNECTIVITY

THE AVERAGE FLOW OF  4/ 1 ---  4/30 IS   7345. CFS!

THE AVERAGE FLOW OF  5/ 1 ---  5/31 IS   7855. CFS!

THE LARGER FLOW BETWEEN THESE TWO SEASON IS    7855. CFS

THE  3.0-YEAR FLOW IS  23600. CFS

THE FLOW IS ESTIMATED BASED ON THE SEASON 10/ 1 ---  9/30

THE 10/ 1 ---  9/30 FLOW-FREQUENCY CURVE USED HERE IS:

 FREQUENCY  FLOW, CFS

     0.014    70000.
     0.028    54300.
     0.042    50000.
     0.056    47600.
     0.069    47400.
     0.083    44700.
     0.097    40900.
     0.111    37500.
     0.125    36600.
     0.139    36600.
     0.153    35000.
     0.167    34100.
     0.181    33700.
     0.194    33700.
     0.208    32800.
     0.222    29600.
     0.236    28600.
     0.250    27100.
     0.264    26200.
     0.278    26000.
     0.292    25900.
     0.306    25900.
     0.319    24000.
     0.333    23600.
     0.347    22700.
     0.361    20300.
```

```
     0.375    18000.
     0.389    17600.
     0.403    16700.
     0.417    16500.
     0.431    16000.
     0.444    14500.
     0.458    13700.
     0.472    13100.
     0.486    12900.
     0.500    12500.
     0.514    11600.
     0.528     9920.
     0.542     9880.
     0.556     9700.
     0.569     9690.
     0.583     9590.
     0.597     9260.
     0.611     8820.
     0.625     8240.
     0.639     7210.
     0.653     6630.
     0.667     6000.
     0.681     5790.
     0.694     5710.
     0.708     5700.
     0.722     5560.
     0.736     5550.
     0.750     5250.
     0.764     5110.
     0.778     5080.
     0.792     4850.
     0.806     4330.
     0.819     4320.
     0.833     4200.
     0.847     4120.
     0.861     3980.
     0.875     3980.
     0.889     3860.
     0.903     3100.
     0.917     2720.
     0.931     2580.
     0.944     2140.
     0.958     1970.
     0.972     1940.
     0.986     1590.
```

Output File Name: Item11.out

```
11. AQUATIC IIE-1 - RATE OF RECRUITMENT OF INSTREAM WOODY MATERIAL

THE  1.5-YEAR FLOW IS   6000. CFS
THE  5.0-YEAR FLOW IS  33340. CFS

BOTH FLOWS ARE BASED ON THE SEASON 10/ 1 ---  9/30
```

```
THE 10/ 1 ---  9/30 FLOW-FREQUENCY CURVE USED HERE IS:

 FREQUENCY  FLOW, CFS

     0.014    70000.
     0.028    54300.
     0.042    50000.
     0.056    47600.
     0.069    47400.
     0.083    44700.
     0.097    40900.
     0.111    37500.
     0.125    36600.
     0.139    36600.
     0.153    35000.
     0.167    34100.
     0.181    33700.
     0.194    33700.
     0.208    32800.
     0.222    29600.
     0.236    28600.
     0.250    27100.
     0.264    26200.
     0.278    26000.
     0.292    25900.
     0.306    25900.
     0.319    24000.
     0.333    23600.
     0.347    22700.
     0.361    20300.
     0.375    18000.
     0.389    17600.
     0.403    16700.
     0.417    16500.
     0.431    16000.
     0.444    14500.
     0.458    13700.
     0.472    13100.
     0.486    12900.
     0.500    12500.
     0.514    11600.
     0.528     9920.
     0.542     9880.
     0.556     9700.
     0.569     9690.
     0.583     9590.
     0.597     9260.
     0.611     8820.
     0.625     8240.
     0.639     7210.
     0.653     6630.
     0.667     6000.
     0.681     5790.
     0.694     5710.
     0.708     5700.
     0.722     5560.
```

```
      0.736     5550.
      0.750     5250.
      0.764     5110.
      0.778     5080.
      0.792     4850.
      0.806     4330.
      0.819     4320.
      0.833     4200.
      0.847     4120.
      0.861     3980.
      0.875     3980.
      0.889     3860.
      0.903     3100.
      0.917     2720.
      0.931     2580.
      0.944     2140.
      0.958     1970.
      0.972     1940.
      0.986     1590.

THE AVERAGE FLOW OF  8/ 1 ---  8/31 IS   1458. CFS!

THE 10-YEAR SEASONAL  21-DAY FLOW IS   3360. CFS

(THE SEASON USED HERE IS:  7/15 ---  9/30)

THE SEASONAL FLOW-FREQUENCY CURVE USED HERE IS:
EXCEEDANCE   FLOW,CFS
      0.014    10900.
      0.028     6310.
      0.042     5400.
      0.056     5200.
      0.069     5090.
      0.083     3620.
      0.097     3450.
      0.111     3000.
      0.125     2800.
      0.139     2710.
      0.153     2690.
      0.167     2420.
      0.181     2400.
      0.194     2340.
      0.208     2280.
      0.222     2250.
      0.236     2180.
      0.250     2160.
      0.264     2050.
      0.278     2000.
      0.292     1970.
      0.306     1920.
      0.319     1900.
      0.333     1730.
      0.347     1640.
      0.361     1610.
      0.375     1560.
      0.389     1510.
      0.403     1480.
```

```
0.417     1460.
0.431     1450.
0.444     1360.
0.458     1330.
0.472     1330.
0.486     1310.
0.500     1300.
0.514     1250.
0.528     1240.
0.542     1180.
0.556     1170.
0.569     1170.
0.583     1080.
0.597     1060.
0.611     1030.
0.625      980.
0.639      951.
0.653      942.
0.667      923.
0.681      904.
0.694      898.
0.708      890.
0.722      880.
0.736      874.
0.750      867.
0.764      860.
0.778      855.
0.792      852.
0.806      700.
0.819      685.
0.833      680.
0.847      659.
0.861      638.
0.875      562.
0.889      549.
0.903      484.
0.917      466.
0.931      463.
0.944      328.
0.958      270.
0.972      237.
0.986      121.
```